KENTUCKY

REASONABLY FORESEEABLE DEVELOPMENT SCENARIO FOR FLUID MINERALS

Prepared for:

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
EASTERN STATES
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The Bureau of Land Management is responsible for the stewardship of our public lands. It is committed to manage, protect, and improve these lands in a manner to serve the needs of the American people for all times. Management is based on the principles of multiple use and sustained yield of our nation's resources within a framework of environmental responsibility and scientific technology. These resources include air, fish and wildlife, minerals, paleontological relics, recreation, rangelands, scenic scientific and cultural values, timber; water, and wilderness.

BLM/ES/PL-08/XXX

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ACRONYMS

ACEC	Area of Critical Environmental Concern
APD	Application for Permit to Drill
AU	Assessment Units
BCF	billion cubic feet
BLM	Bureau of Land Management
BOPD	barrels of oil per day
CBNG	Coal Bed Natural Gas
EIS	Environmental Impact Statement
EOR	Enhanced Oil Recovery
ESA	Endangered Species Act
EIS	Environmental Impact Statement
JFO	Jackson Field Office
KDOGC	Kentucky Division of Oil and Gas Conservation
MMBO	million barrels of oil
ROD	Record of Decision
RMP	Resource Management Plan
SMA	Surface Management Agency
TCF	trillion cubic feet
TPS	Total Petroleum Systems
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	U.S. Geological Survey

Summary

1.0 INTRODUCTION

The Bureau of Land Management's Jackson Field Office is located in Jackson, Mississippi, and is responsible for 11 southern states: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. The Jackson Field Office manages approximately 34.25 million acres of federal mineral estate in the eastern portion of the United State. Of this approximately 2.26 million mineral acres are located in Kentucky where oil and gas leases are active in the Daniel Boone and Jefferson National Forests.

The Reasonable Foreseeable Development Scenario (RFDS) forecasts fluid mineral exploration, development, and production for the planning area for the next ten years. The RFDS assumes a baseline scenario in which no new policies are introduced and all areas not currently closed to leasing and development are opened for oil and gas activity.

Interagency Reference Guide - Reasonably Foreseeable Development Scenarios and Cumulative Effects Analysis for Oil and Gas Activities on Federal Lands in the Greater Rocky Mountain Region" (USDI 2002), "Policy for Reasonably Foreseeable Development Scenario (RFD) for Oil and Gas (BLM WO IM No. 2004-089) and Planning for Fluid Minerals Supplemental Program Guidance (BLM Handbook H-1624-1) guided the criteria and analyses methods used in this RFD.

1.1 Discussion of Determining Oil and Gas Resource Potential

Potential accumulations of oil and gas are described in Section 2. Non-BLM land within the state may be included in this section when it provides a better understanding of resource potential on BLM property. These determinations were made using the geologic criteria provided by reference in Section 2. Also contained in Section 2 are descriptions of stratigraphy, structure, historic oil and gas activities, as well as relevant studies done in the area. Potential reservoir rocks, source rocks, and existing stratigraphic and structural traps are discussed in detail.

1.2 Methodology for Predicting Future Oil and Gas Exploration and Development Activity

Section 7 predicts the type and intensity of future oil and gas exploration and development activities. These forecasts are determined by an area's geology, and historical and present activity, as well as factors such as economics, technological advances, access to oil and gas areas, transportation, and access to processing facilities. Economics, technology, and other factors may be hard to predict because of their complex nature and rapid rate of change. Projections of oil and gas activities are based upon present knowledge. Future changes in global oil and gas markets, infrastructure and transportation, or technological advancements, may affect future oil and gas exploration and development activities within the state.

1.3 Relating the Potential for Resource Occurrence to Potential for Activity

Predicted oil and gas activity does not necessarily correlate with geologic potential for the presence of hydrocarbons. Although the geology of an area may suggest the possibility of oil and gas resources, actual exploration and development may be restricted by high exploration costs, low oil and gas prices, or difficulty accessing the area due to lease stipulations. Thus a small area may have a high resource potential, yet have a low exploration and development potential due to severe restrictions on access. Conversely, technological advancements or an increase in oil and gas prices could result in oil and gas activities in areas regarded as having low potential for occurrence.

2.0 DESCRIPTION OF THE GEOLOGY OF KENTUCKY

The surface geology of the Commonwealth of Kentucky is dominated by exposures of Paleozoic rocks that range in age from Ordovician to Pennsylvanian. Exposures of younger Mesozoic and Tertiary aged units are confined to the very southwestern tip of the state in the area known as the Jackson Purchase. The name for this area derives from the purchase of these lands from local Indian tribes in the early 1800's by Andrew Jackson. Quaternary aged sediments in the state are generally confined to areas associated with rivers and smaller tributaries (McDowell, Robert C, 1985). (See Figure 1 Geologic map of Kentucky).

The distribution of these exposures and the general topography and physiography of the region are to a large extent controlled by the parts of four major structural features that are present within the commonwealth. These include parts of the Illinois and Appalachian basins, a segment of the Cincinnati Arch, and a small part of the northeastern most extension of the Mississippi Embayment (Landes, K. K. 1970). These regionally scaled structural features include smaller localized features that include folded geologic structures that have been cut by individual fault and fault trends. Figure 2 shows the location of these regional structural features.

Figure 1: Geologic Map of Kentucky

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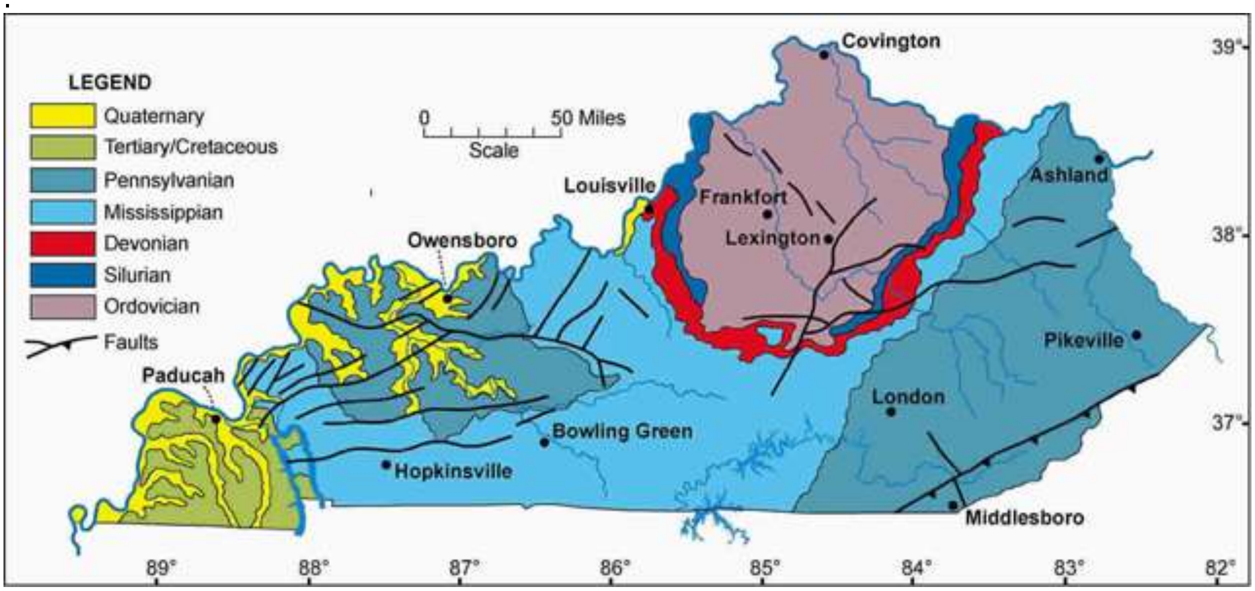
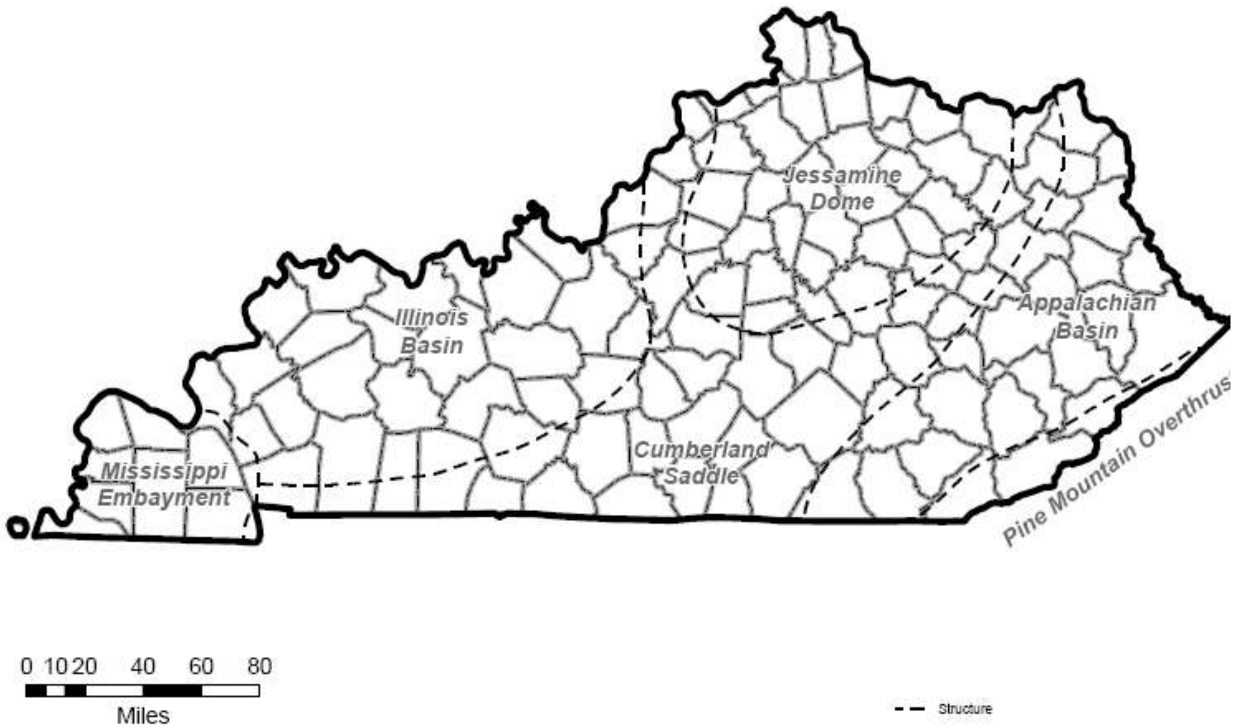


Source: Kentucky Geological Survey 1988

Figure 2: Structural Elements of Kentucky



Source: USGS, 2001

2.1 Subsurface Stratigraphy and Structure

The subsurface stratigraphy and structure related to the occurrence of oil and gas resources in Kentucky is divided into three primary sub-regions which include: Central Kentucky Sub-region, the Eastern Kentucky Sub-region, and the Western Kentucky Sub-region which also includes the area of Jackson Purchase. The regional structural controls which effect the distribution of the geologic surface exposures and the general physiography of the commonwealth to a large extent also control the distribution of subsurface rock units and in turn effect the distribution of oil and gas occurrences. These regional structures and stratigraphic relationships are discussed for each sub-region.

2.1.1 Central Kentucky Sub-Region

The Central Kentucky Sub-region is located in north-central and south-central Kentucky and coincident with the crestal and flank areas of the Cincinnati arch which extends through Kentucky (Landes, K.K., 1970).

The Cincinnati arch is a positive geologic structural feature that represents an extension of the Kankakee and Findley arches which extend southward from Illinois and Ohio into Kentucky. The arch continues southward across central Kentucky into Tennessee where it terminates at Nashville dome in central Tennessee. Key structural expressions of the arch in Kentucky are the Jessamine dome (Lexington dome), the Lexington, Kentucky River fault systems as well as segments of the Irvine-Paint Creek fault system, and the so called “Cumberland saddle”, which consists of the structural sag between the Jessamine dome of Kentucky and the Nashville dome of Tennessee (Landes, K.K., 1970 and McDowell, Robert C., 1985).

This sub-region contains reservoirs that are productive of both oil and natural gas. These reservoirs consist of both carbonates and clastic rock units that range in age from the Ordovician System through Mississippian System (Kentucky Geological Survey, website, 1998 and Kentucky Geological Survey, website, Oil and Gas Overview, 2002). Figure 3 shows a generalized stratigraphic column for reservoir units in the Central Kentucky Sub-region.

The bulk of these reservoirs are found at drilling depth that are less than 1,000 feet in depth to drilling depths that are between 1,000 and 3,000 feet (Kentucky Geological Survey, website, Oil and Gas in Kentucky, 1998). Annual crude oil and natural gas production for counties located in this sub region was reported as 264,485 barrels of oil and 991,022 thousand cubic feet of gas for the year 2005 (Kentucky Geological Survey, website, Oil and Gas Activity Data, 2008). These volumes accounted for 10.78% of the total annual oil production for the commonwealth and 1.07% of the total annual natural gas production for the commonwealth during that year.

2.1.2 Western Kentucky Sub-Region

The Western Kentucky Sub-region is located in west and west-central Kentucky and coincident with the very southern most part of the Illinois Basin which extends from the northwest into Kentucky and includes the Pennsylvanian rock units that form the Kentucky western coal field. Important structural features within the basin in Kentucky are the Rough Creek and Pennyrile fault systems, and the Moorman syncline (McDowell, Robert C., 1985).

The Rough Creek fault system is a major east – southeast trending fault system which crosses the southern end of the basin in Kentucky and forms the northern boundary of the Moorman syncline. The Rough Creek fault zone is composed of a number of high angle, down to the south, normal faults which form a series of grabens and horsts and includes areas of sharp folding associated with that fault system (McDowell, Robert C., 1985). Away from this fault system gentler folding prevails (Landes, K, K., 1970). The east–west trending Pennyrile fault system represents the southern boundary of the Moorman syncline. The Pennyrile fault system is similar in form to the Rough Creek fault system however it has fewer faults with less displacement (McDowell, Robert C., 1985).

While this sub-region contains reservoirs that are productive of both oil and natural gas, oil production dominates over that of natural gas. The productive reservoirs consist of both clastic and carbonate rock units that range in age from the Ordovician System into the Pennsylvanian System (Kentucky Geological Survey, website, 1998 and Kentucky Geological Survey, website, Oil and Gas Overview, 2002). Hydrocarbon accumulations are largely structurally controlled but distribution of reserves may depend on local porosity development (Landes, K.K., 1970). Figure 4 shows a generalized stratigraphic column for reservoir units in the Western Kentucky Sub-region.

The majority of these reservoirs are found at drilling depths that are between 1,000 and 3,000 feet but some areas within the sub-region have production at depths of less than 1000 feet (Kentucky Geological Survey, website, Oil and Gas in Kentucky, 1998).

Annual crude oil and natural gas production for counties located in this sub region was reported as 1,133,260 barrels of oil and 628,001 thousand cubic feet of gas for the year 2005 (Kentucky Geological Survey, website, Oil and Gas Activity Data, 2008). These volumes accounted for 46.18% of the total annual oil production for the commonwealth and less than 1 % of the total annual natural gas production for the commonwealth during that year.

2.1.3 Eastern Kentucky Sub-Region

The Eastern Kentucky Sub-region is located in eastern Kentucky and is considered a part of the much larger Appalachian province which extends northeastward into parts of Ohio, Virginia, and West Virgin and beyond. The eastern part of Kentucky is considered part of the Appalachian basin with the very southeastern part of the state in the Appalachian fold-and-thrust province (McDowell, Robert C., 1985).

That part of the Appalachian basin located in Kentucky contains important structural features which include parts of the Irvine-Paint Creek fault system and the Pine Mountain thrust fault (McDowell, Robert C., 1985). Accumulations in this area are structurally controlled or are the result of variation in reservoir porosity and permeability development on and off structure (Landes, K. K., 1970).

This sub-region contains reservoirs that are productive of both oil and natural gas with the eastern most portion of this area being largely productive of natural gas. The productive horizons consist of sandstones; carbonate rock and shale reservoirs that range in age from the Ordovician System into the Pennsylvanian System (Kentucky Geological Survey, website, Oil and Gas in Kentucky, 1998 and Kentucky Geological Survey, website, Oil and Gas Overview, 2002). Figure 5 shows a generalized stratigraphic column for reservoir units in the Eastern Kentucky Sub-region.

The majority of these reservoirs are found at drilling depths that are between 1,000 and 3,000 feet but some areas within the region require drilling to depths greater than 3,000 feet (Kentucky Geological Survey, website, Oil and Gas in Kentucky, 1998). Annual crude oil and natural gas production for counties located in this sub region was reported as 1,056,197 barrels of oil and 91,003,966 thousand cubic feet of gas for the year 2005 (Kentucky Geological Survey, website, Oil and Gas Activity Data, 2008). These volumes accounted for 43.04% of the total annual oil production for the state and less than 98.25 % of the total annual natural gas production for the commonwealth during that year.

The Devonian Shale (Ohio Shale) has been and continues to be an attractive exploration target in Eastern Kentucky. This unconventional reservoir will continue to see exploration activity in this area. As with many unconventional reservoirs projection of reservoir quality and ultimate performance remains difficult to predict. Recent work by the Kentucky Geological Survey has shown that the maximum average daily production during the first 6 months is an adequate indicator of future well performance and that the best wells can be expected to make 20 MMcf in first year and 100 MMcf after 5 years (Nuttall, B.C., 2007).

Figure 3: Generalized Stratigraphic Column - Reservoir Units in the Central Kentucky Sub-region

Era	System	Formation / Reservoir
Paleozoic	Mississippian	Salem Limestone Warsaw Limestone Fort Payne Formation (Corder, Stray) New Providence Formation (Beaver Creek)
	Devonian	New Albany Shale, Chattanooga Shale Knob Lick Sandstone (Hardin) Jeffersonville Limestone (Grand Tower) Dutch Creek Sandstone Clear Creek Limestone Brownsport Group
	Silurian	Louisville Limestone (Lego) Laurel Dolomite (Blue sand) Brassfield Dolomite (Yellow Cap)
	Ordovician	Cumberland Formation Leipers Limestone (Fannys Creek, Modoc) Garrard Siltstone Clays Ferry Formation (Granville) Lexington Limestone (Sunnybrook, Trenton) High Bridge Group (Stones River, Murfreesboro) Wells Creek Formation St. Peter Sandstone Knox Dolomite

Figure 4: Generalized Stratigraphic Column - Reservoir Units in the Western Kentucky Sub-region

Era	System	Formation / Reservoir
Paleozoic	Pennsylvanian	Sturgis (Lisman) Formation Carbondale Formation Tradewater Formation Caseyville Formation
	Mississippian	Clore Formation Palestine Sandstone Menard Formation (Chapman) Waltersburg Sandstone (Fuqua sand) Vienna Limestone Tar Springs Sandstone (Jett sand) Glen Dean Limestone Hardinsburg Sandstone Haney Limestone Big Clifty Sandstone (Jackson sand) Cypress Sandstone (Barlow sand) Reelsville Limestone (Upper Paint Creek Limestone) Sample Sandstone (Paint Creek sand) Beaver Bend Limestone (Lower Paint Creek Limestone) Bethel Sandstone (Benoist) Renault Limestone Aux Vases Formation Ste. Genevieve Limestone (O'Hara, Rosiclare, McClosky) St. Louis Limestone Salem Limestone Warsaw Limestone Fort Payne Formation
	Devonian	New Albany Shale Jeffersonville Limestone (Grand Tower) Dutch Creek Sandstone Clear Creek Limestone
	Silurian	Brownsport Formation Laurel Dolomite
	Ordovician	Kimmswick Limestone (Lexington, Trenton)

Figure 5: Generalized Stratigraphic Column - Reservoir Units in the Eastern Kentucky Sub-region

Era	System	Formation / Reservoir
Paleozoic	**Pennsylvanian**	Lee Formation (Salt Sand)
	Mississippian	Pennington Formation (Maxon, Ravencliff) Newman Limestone (Big Lime) Borden Formation (Injun, Keener, Weir) Berea Sandstone (Grit)
	Devonian	Ohio Shale Onondaga, Huntersville Limestone (Corniferous)
	Silurian	Salina Dolomite (Corniferous) Lockport Dolomite (Corniferous) Keefer Sandstone (Big Six) Clinch Sandstone (Clinton sand)
	Ordovician	Lexington Limestone (Trenton, Trenton-Black River) High Bridge Group (Stones River, Murfreesboro) St. Peter Sandstone Knox Group, Beekmantown Dolomite
	Cambrian	Knox Group, Copper Ridge Dolomite Rome Formation

3.0 SUMMARY OF USGS PLAY DESCRIPTIONS

3.1 Oil and Gas Assessment

The most recent oil and gas assessment by the USGS for the Cincinnati Arch, Appalachian Badin and Illinois Basin provinces was completed in 1995. In each of those assessments of those provinces a number of conventional and unconventional oil and gas plays were assessed which might have an impact on oil and gas exploration and production activity in Kentucky.

The following is a summary of those 1995 province assessments and includes only very general information relative to the play. The primary source materials for this summary presentation are the geologic reports for each of the province assessments.

3.2 Illinois Basin in Western Kentucky

The assessment of the Illinois Basin province by the USGS recognized three total petroleum systems (TPS) that included parts of north-western Tennessee (USGS, 2007). The total petroleum systems included: a Precambrian to Cambrian TPS, Ordovician Ancell/Maquoketa TPS, and a Devonian to Mississippian New Albany TPS.

3.2.1 Precambrian to Cambrian TPS

The Precambrian to Cambrian TPS is comprised of three assessment units: the Precambrian to Cambrian Rift-Fill AU, the Cambrian Mount Simon to Eau Claire AU, and the Cambrian to Ordovician Knox Group AU (USGS, 2007). The assessment units of the Precambrian to Cambrian TPS were not assessed quantitatively by the USGS and therefore the USGS did not provide numerical values for Total Undiscovered Resources. The USGS fact sheet for the Illinois Basin is provided in Appendix A.

3.2.2 Ordovician Ancell/Maquoketa TPS

The Ordovician Ancell/Maquoketa TPS is comprised of two assessments units; Ordovician Dutchtown to Galena AU, and Ordovician St. Peter/Everton AU. The USGS did not quantitatively assess the Ordovician St. Peter/Everton AU therefore the USGS did not provide numerical values for Total Undiscovered Resources. The USGS fact sheet for the Illinois Basin is provided in Appendix A.

3.2.3 Devonian to Mississippian TPS

The Devonian to Mississippian TPS is comprised of eleven assessment units: Pennsylvanian Sandstones AU, Upper Mississippian Sandstones AU, Lower Mississippian Carbonates AU, Lower Mississippian Borden AU, Middle Devonian Carbonates AU, Middle Devonian Dutch Creek Sandstone AU, Lover Devonian Carbonates AU, Upper Silurian Carbonates (Reef) AU, Upper Silurian Calcareous Siltstones AU, Lower Silurian Carbonates AU, and Cambrian to Ordovician Carbonates Cumberland Saddle AU. The quantitative assessment values developed by the USGS are provided in Appendix B.

3.3 Cincinnati Arch Province in Central Kentucky

The assessment of the Cincinnati Arch province by the USGS recognized four conventional plays and one unconventional play that included parts of central and south-central Kentucky located on the Cincinnati Arch (Ryder, 1996a). Those conventional plays included: a Cambrian and Lower Ordovician Carbonate Play, Middle and Upper Ordovician Carbonate Play, a Silurian and Devonian Carbonate play, and a Mississippian Carbonate Play. The unconventional play recognized was a Devonian Black Shale Gas Play.

3.3.1 Cambrian and Lower Ordovician Carbonate Play

The Cambrian and Lower Ordovician Carbonate Play is an oil play with associated gas trapped in a karstic dolomite by Knox unconformities and small anticlines

(Ryder, 1996a). The Cincinnati Arch area is predicted to have the potential for small fields with production around 1 MMBO and 6 BCF of gas. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.3.2 Middle and Upper Ordovician Carbonate Play

The Middle and Upper Ordovician Carbonate Play is an oil play with associated gas trapped in dolomite and bioclastic limestones by stratigraphic traps, fracture zones and small anticlines (Ryder, 1996a). The Cincinnati Arch area is predicted to have the potential for small fields with production around 1 MMBO and 6 BCF of gas. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.3.3 Silurian and Devonian Carbonate Play

The Silurian and Devonian Carbonate Play is an oil and gas play trapped in Silurian and Devonian carbonates by truncations, facies-change, and combination traps (Ryder, 1996a). The Cincinnati Arch area is predicted to have the potential for small fields with production around 1 MMBO and 6 BCF of gas, as previous development has exhausted larger fields in the play area. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.3.4 Mississippian Carbonate Play

The Mississippian Carbonate Play is an oil and gas play trapped in Mississippian bioherms by facies-change, and combination traps (Ryder, 1996a). The Cincinnati Arch area is predicted to have no potential for production around 1 MMBO and 6 BCF of gas, as previous development has exhausted larger fields in the play area. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.3.5 Devonian Black Shale Gas Play (Chattanooga Shale)

The Devonian Black Shale Gas Play is an unconventional continuous-Type Play in which gas has been generated and trapped in fractured shales of the Upper Devonian Chattanooga and New Albany Shales (Ryder and Hatch, 1996). The Cincinnati Arch area is predicted in the 1995 assessment to have the potential for small amounts of undiscovered gas, this data may be out of date as test wells have been developed in the shale and technology has advanced to facilitate production of this gas. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.4 Appalachian Basin Province in Eastern Kentucky

The assessment of the Appalachian Basin province by the USGS recognized eleven conventional plays and five unconventional plays that included parts of eastern Kentucky located in the Appalachian Basin. Those conventional plays included: a play centered in the Rome Trough, a Beekmantown/Knox Carbonate Oil/Gas Play, a Rose Run / Gatesburg / Theresa Sandstone Gas Play, a Trenton/Black River Carbonate Oil/Gas, a Keefer/Big Six Sandstone Gas Play, a "Corniferous Limestone" /Big Six Sandstone Oil/Gas Play, a Silurian Carbonate Gas Play, a Devonian Carbonate Gas Play, a Oriskany Sandstone Gas Play, a Mississippian and Pennsylvanian Sandstone/Carbonate Play, and a Tuscarora Sandstone Gas Play. The unconventional plays listed as being included in Kentucky portions of the Appalachian Basin Province included: a Clinton/Medina Sandstone Gas Play with medium potential, a Clinton/Medina Sandstone Gas Play with low potential, and three Devonian Black Shale Gas Plays included in parts of Eastern Kentucky.

3.4.1 Rome Trough Play

The Rome Trough Play is a hypothetical gas trap play reservoired in shallow-marine to peritidal carbonate and sandstones trapped within the rift by basement-controlled fault blocks and anticlines (Ryder, 1996b). The Appalachian Basin area has the potential for several undiscovered gas fields of greater than 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.4.2 Rose Run/Gatesburg/Theresa Sandstone Gas Play

The Rose Run/Gatesburg/Theresa Sandstone Gas Play is a conventional gas trap play reservoired in shelf sandstones by truncation traps, paleo-topographic highs, and low-amplitude, basement-controlled anticlines (Ryder, 1996b). The Appalachian Basin area has the potential for a modest number of undiscovered gas fields of greater than 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.4.3 Beekmantown/Knox Carbonate Oil/Gas Play

The Beekmantown/Knox Carbonate Oil and Gas Play is a conventional play with oil and gas in dolomite reservoirs trapped by truncations, paleo-topographic highs, and low amplitude anticlines (Ryder, 1996b). The Appalachian Basin area has the potential for a modest number of undiscovered oil and gas fields of greater than 1 MMBO or 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.4.4 Trenton/Black River Carbonate Oil/Gas Play

The Trenton/Black River Carbonate Oil and Gas Play is a conventional play with the oil and gas in platform limestone reservoirs trapped by low amplitude anticlines, dolomitized fracture zones, and natural fractures (Ryder, 1996b). The Appalachian Basin area has the potential for a modest number of undiscovered oil and gas fields of greater than 1 MMBO or 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.4.5 Keefer/Big Six Sandstone Gas Play

A Keefer/Big Six Sandstone Gas Play is a gas trap play reservoired in the Keefer, Big Six, Oneida, and Herkimer Sandstones by facies-change stratigraphic traps, combination traps, and low-amplitude anticlines (Ryder, 1996b). The Appalachian Basin area has the potential for a small number of undiscovered gas fields of greater than 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.4.6 "Corniferous" Limestone/Big Six Sandstone Oil/Gas Play

The "Corniferous" Limestone/Big Six Sandstone Oil/Gas Play is a gas and oil trap play reservoired in "Corniferous" limestone and Big Six sandstone by truncation, facies-change, and combination traps, and low-amplitude anticlines (Ryder, 1996b). The Appalachian Basin area has no potential for undiscovered oil and gas fields of greater than 1 MMBO or 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.4.7 Silurian Carbonate Gas Play

The Silurian Carbonate Gas Play is a gas and local oil trap play reservoired in platform carbonates by facies-change stratigraphic and combination traps, and low-amplitude basement controlled anticlines. The Appalachian Basin area has the potential for a modest number of undiscovered gas fields of greater than 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.4.8 Devonian Carbonate Gas Play

The Devonian Carbonate Gas Play is gas trap play reservoired in the Onondaga and Columbus Limestone trapped by faulted ramp anticlines, imbricate thrust slices, and fractures zones controlled by bedding-plane detachments (Ryder, 1996b). The

Appalachian Basin area has the potential for a small number of undiscovered gas fields of greater than 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.4.9 Oriskany Sandstone Gas Play

The Oriskany Sandstone Gas Play is a gas and local oil trap play reservoired in the Oriskany sandstone trapped by highly faulted ramp anticlines, salt anticlines, imbricate fault slices, and combination traps (Ryder, 1996b). The Appalachian Basin area has the potential for a small number of undiscovered gas fields of greater than 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.4.10 Mississippian and Pennsylvanian Sandstone/Carbonate Play

The Mississippian and Pennsylvanian Sandstone/Carbonate Play is an oil and gas play reservoired in shallow-marine sandstone and shelf limestone trapped by facies-change stratigraphic, combination, unconformity and local anticlinal traps (Ryder, 1996b). The Appalachian Basin area has the potential for a small number oil and gas fields of greater than 1 MMBO or 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.4.11 Tuscarora Sandstone Gas Play

The Tuscarora Sandstone Gas Play is a gas trap play reservoired in the Tuscarora Sandstone by low-amplitude basement-controlled anticlines (Ryder, 1996b). The Appalachian Basin area has the potential for a modest number of gas fields of greater than 6 BCFG. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

3.4.12 Devonian Black Shale Gas Play (Chattanooga Shale)

The Devonian Black Shale Gas Play is an unconventional continuous-Type Play in which gas has been generated and trapped in fractured shales of the Upper Devonian Chattanooga and New Albany Shales. The Cincinnati Arch area is predicted in the 1995 assessment to have the potential for small amounts of undiscovered gas, this data may be out of date as test wells have been developed in the shale and technology has advanced to facilitate production of this gas. A more detailed description of the play developed by the USGS for the 1995 US Oil and Gas Assessment can be found in Appendix B.

4.0 PAST AND PRESENT OIL AND GAS EXPLORATION ACTIVITY

4.1 Drilling Activity

Drilling varies from region to region in Kentucky. Figure 6 shows the average number of drilling permits that have been issued per year by region within the state of Kentucky. The graph shows the number of drilling permits issued in the western and central Kentucky regions have been declining since the early 1980's. While the eastern Kentucky region has shown a relatively consistent number of drilling permits over the years, with a recent increase in the last ten years. Figure 6 also shows that overall drilling in Kentucky had been on a decline from 1981 to 1999, since 2000 there has been an approximate two fold increase in the number of drilling permits issued per year in Kentucky.

Figure 7 plots the annual number of new oil wells put into production between 1980 and 2007 by region. The graph shows the central region of Kentucky on average has had the largest number of new oil wells. The number of new oil wells drilled in the each region of Kentucky has been declining since the early 1980's with the largest decline occurring during the 1980's. Since the late 1990's the number of new oil wells has been increasing with the greatest increase being seen in the central Kentucky region. Slowly rising product prices since 2000 have propelled drilling from its low-point in 1998 to the present-day levels.

Figure 8 plots the total number of new natural gas wells by region. The graph of new gas wells drilled in Kentucky is dominated by the activity in the eastern region of Kentucky. While the number of new gas wells in the western and central regions of Kentucky show annual fluctuates with a declining trend over the last 25 years, the overall increase in eastern Kentucky gas wells can be seen from 1995 to 2006.

Figure 6: Drilling Permits Issued in Kentucky by Region per year 1980 to 2006

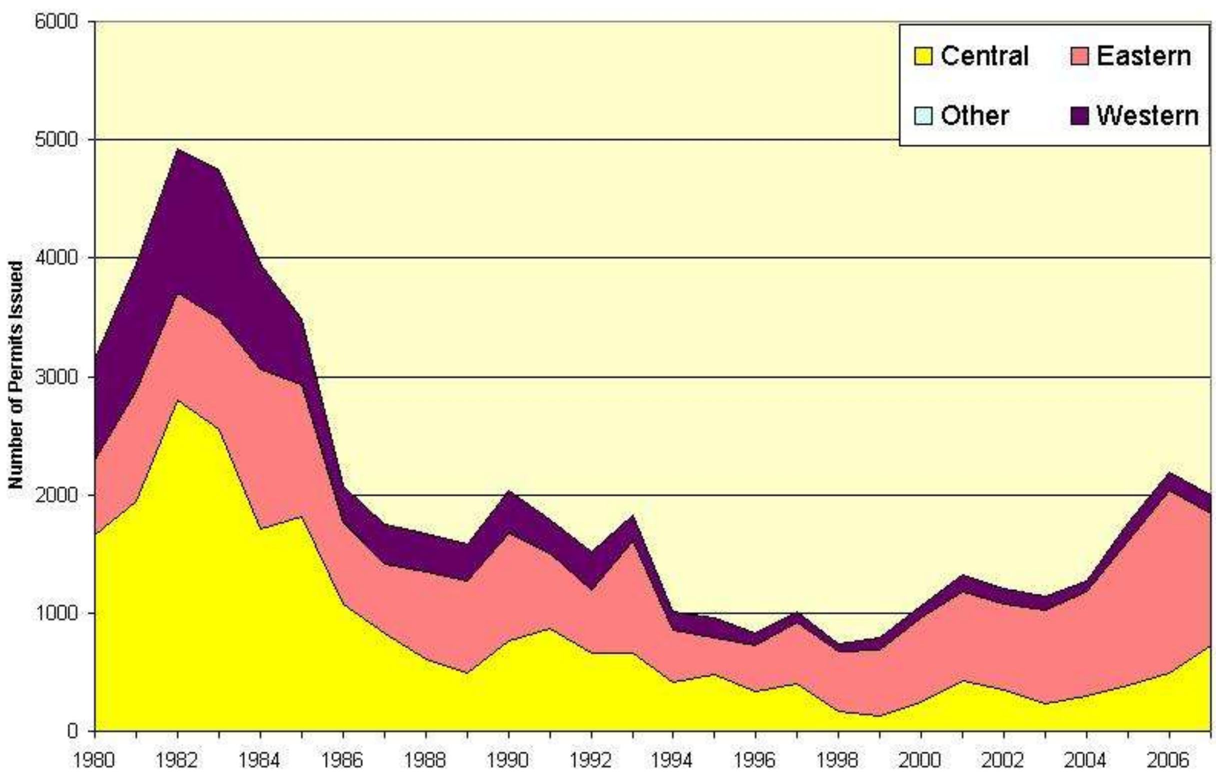


Figure 7: New Oil Wells Drilled in Kentucky by Region per year 1980 to 2006

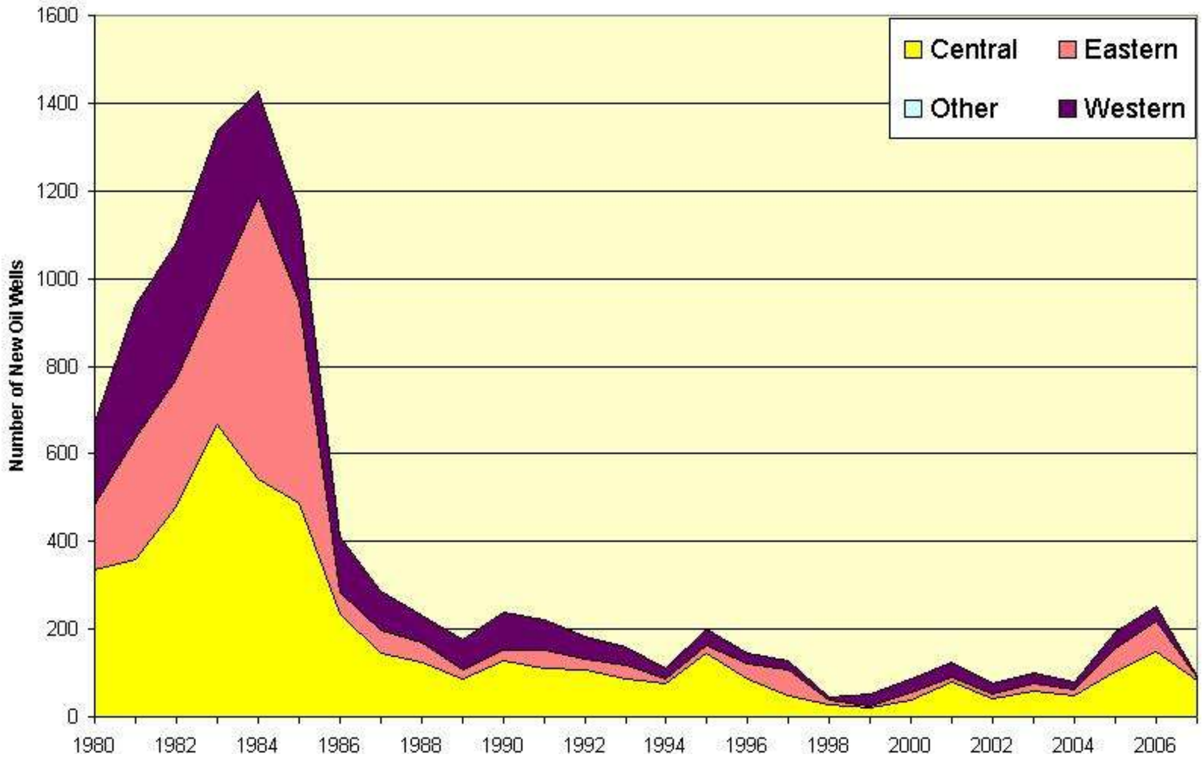
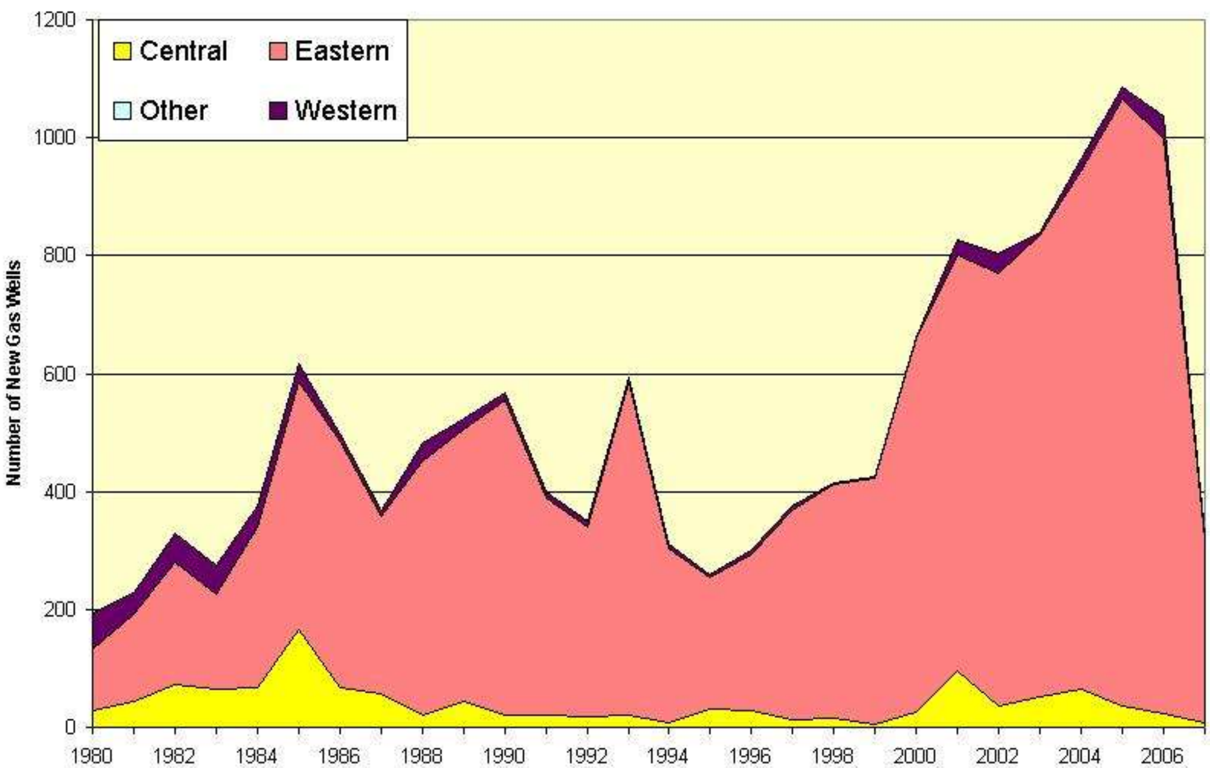


Figure 8: New Gas Wells Drilled in Kentucky by Region per year 1980 to 2006



4.2 Exploratory Drilling and Success Rates

4.2.1 Central Kentucky Region

The central Kentucky region is associated with the Cincinnati Arch play. The region has received a moderate level of oil production over the past 20 years. During the 1980's the central Kentucky region was the area with the largest percentage of drilling permit activity (see Figure 6). Since 1999 drilling permits have started to increase again with the number of permits having more than tripled from 1999 to 2006. Figure 9 plots the success of drilling activities in each of the regions of Kentucky by noting the percent of dry holes drilled in each region. Figure 9 shows that the Central region has consistently been the area with the lowest success rate (highest percent of dry holes) of the three regions in Kentucky since 1980.

Table 1 ranks the counties of central Kentucky by drilling permit activity between the years 2001 to 2006. The most active counties – Clinton, Adair, and Metcalfe – all drilled more than 300 wells over these years and are located in the south central portion of the state. Table 1 also shows the ranking of counties based on the number of permits that have been issued form 1980-2006. A comparison of the two sets of data shows that four of the top five counties for permits issued between 2001 and 2006 are also in the top five for 1980 to 2006.

4.2.2 Western Kentucky Region

The western Kentucky region is associated with the Illinois Basin play. The region has received a highest level of oil development and minimal natural gas development over the past 20 years compared to the other two regions of Kentucky. Since 1980 the western Kentucky region has been the area with the lowest percentage of drilling permit activity (see Figure 6). Since 1990's drilling permits have remained relatively constant in the Western Kentucky region. Figure 9 plots the success of drilling activities in each of the regions of Kentucky by noting the percent of dry holes drilled in each region. Figure 9 shows that the western region has consistently average between 20% and 30% dry holes since 1980.

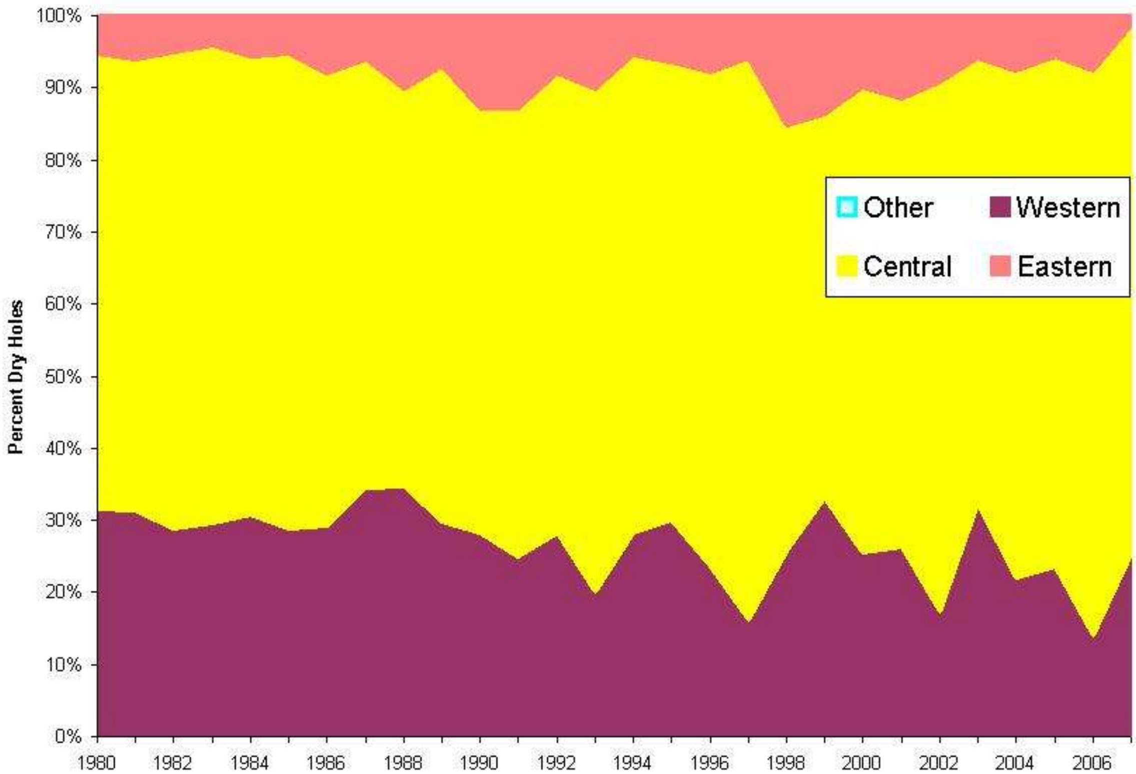
Table 2 ranks the counties of western Kentucky by drilling permit activity between the years 2001 to 2006. The most active counties – Daviess, Henderson, and Muhlenberg – all drilled around 100 wells over these years and are located in the north western portion of the state. Table 2 also shows the ranking of counties based on the number of permits that have been issued form 1980-2006. A comparison of the two sets of data shows that four of the top five counties for permits issued between 2001 and 2006 are also in the top five from 1980 to 2006.

4.2.3 Eastern Kentucky Region

The eastern Kentucky region is associated with the Appalachian Basin play. The region has received a highest level permit activity over the last 5 years. Since 1980 the eastern Kentucky region has been the area with the highest percentage of natural gas production and has shown the greatest increase in permit activity over the last ten years (see Figure 6). Figure 9 plots the success of drilling activities in each of the regions of Kentucky by noting the percent of dry holes drilled in each region. The graph shows that the eastern region has consistently averaged less than 15% dry holes since 1980.

Table 3 ranks the counties of eastern Kentucky by drilling permit activity between the years 2001 to 2006. The most active counties – Knox, Letcher, Magoffin, and Pike – all drilled more than 500 wells over these years and with three of the counties located in the south eastern corner of the state. Table 3 also shows the ranking of counties based on the number of permits that have been issued form 1980-2006. A comparison of the two sets of data shows that two of the top five counties for permits issued between 2001 and 2006 are also in the top five from 1980 to 2006.

Figure 9: Percentage of Dry Holes Drilled in Kentucky by Region



4.3 New Field and Reservoir Discoveries

There are no new fields or reservoir discoveries of significance that will yield substantial production in the foreseeable short term future.

Table 1: Central Kentucky Counties Ranked by Drilling Permits Issued, 1980-2006 and 2001-2006

Central			
County	Permits 2001-2006	County	Permits 1980- 2006
Clinton	540	Clinton	5170
Adair	316	Cumberland	4236
Metcalfe	311	Warren	2674
Cumberland	181	Adair	2036
Meade	108	Metcalfe	1617
Hart	97	Barren	1518
Warren	93	Russell	781
Edmonson	81	Allen	770
Wayne	74	Green	737
Green	72	Wayne	679
Barren	66	Edmonson	648
Pulaski	66	Monroe	626
Russell	56	Hart	470
Monroe	36	Pulaski	413
Lincoln	26	Meade	240
Larue	24	Simpson	192
Hardin	13	Casey	167
Allen	11	Taylor	136
Taylor	6	Lincoln	84
Clark	4	Hardin	48
Nelson	2	Larue	45
Jefferson	1	Bullitt	29
		Grant	29
		Marion	26
		Montgomery	24
		Madison	21
		Bath	19
		Clark	11
		Garrard	10
		Nelson	9
		Mason	7
		Owen	7
		Gallatin	6
		Mercer	6
		Scott	5
		Jefferson	4
		Carroll	3
		Boyle	2
		Fleming	1
		Franklin	1
		Henry	1
		Pendleton	1

Table 2: Western Kentucky Counties Ranked by Drilling Permits Issued, 1980-2006 and 2001-2006

Western			
County	**Permits 2001-2006**	**County**	**Permits 1980- 2006**
Daviess	128	Muhlenberg	1564
Muhlenberg	107	Henderson	1514
Henderson	88	Daviess	1277
Ohio	85	Ohio	931
Breckinridge	63	Christian	782
Webster	63	Mclean	713
Christian	60	Hopkins	615
Union	59	Union	590
Caldwell	50	Webster	415
Butler	48	Hancock	323
Mclean	45	Todd	304
Hancock	42	Butler	299
Grayson	30	Logan	218
Hopkins	28	Grayson	205
Todd	13	Breckinridge	154
Logan	9	Caldwell	72
Crittenden	5	Crittenden	23
Lyon	3	Trigg	7
Livingston	1	Livingston	5
		Lyon	3

Table 3: Eastern Kentucky Counties Ranked by Drilling Permits Issued, 1980-2006 and 2001-2006

Eastern			
County	**Permits 2001-2006**	**County**	**Permits 1980- 2006**
Pike	940	Pike	3286
Magoffin	768	Lee	1995
Letcher	692	Whitley	1519
Knox	640	Magoffin	1511
Bell	473	Clay	1349
Perry	420	Knox	1222
Knott	397	Floyd	1043
Harlan	353	Knott	1041
Floyd	340	Letcher	1003
Leslie	299	Leslie	921
Lawrence	292	Perry	817
Clay	263	Lawrence	778
Whitley	237	Martin	761
Martin	219	Bell	614
Johnson	149	Wolfe	553
Lee	147	Harlan	488
Morgan	106	Johnson	417
Breathitt	77	Breathitt	399
Wolfe	65	Powell	362
McCreary	56	Estill	293
Elliott	38	Elliott	271
Laurel	30	McCreary	250
Owsley	17	Morgan	217
Carter	5	Laurel	158
Estill	5	Greenup	115
Rowan	1	Owsley	106
		Boyd	63
		Menifee	40
		Jackson	40
		Carter	30
		Rockcastle	24
		Rowan	10
		Lewis	4

5.0 OIL AND GAS ACTIVITY IN KENTUCKY

This section deals with the current status of oil and gas activity in Kentucky based on information provided by both public and private sources. Information includes; leasing activity, well spacing requirements, drilling permits by county, Drilling practices, production statistics, oil and gas characteristics, oil and gas prices, operational costs (drilling, completion, and gathering and transmission), conflicts with other mineral development, and gas storage fields.

5.1 Leasing Activity

Leasing activity in Kentucky is on-going in all three of the primary oil and gas producing areas of the Commonwealth. Lease plays include unconventional resource plays for the Ohio Shale in eastern Kentucky and the New Albany Shale of western Kentucky.

While initial leasing costs vary they generally tend to range from $10.00 to $20.00 per acre with somewhat higher initial costs associated with acreage in areas of proven and sustainable production (Bender, R., 2008). Cost associated with title preparation raise the initial leasing cost into the range of $40.00 to $50.00 per acre.

5.2 Well Spacing Requirements

Well spacing requirements for oil and gas wells drilled in Kentucky are subject to the rules and regulations of the Department Natural Resources, Division of Oil and Gas. Spacing requirements fall under those set by specific pool or field rules issued by the Division of Oil and Gas upon notice and hearing and those covered under the general rules and regulations of Kentucky Division of Oil and Gas Conservation (KDOGC).

The specific KDOGC regulation and statutes which deals with spacing requirements not covered under established pool or field rules are found in Kentucky Administrative Regulations. Title 805-Chapter 1 and Kentucky Revised Statues Chapter 353. While there are certain exceptions available under specific conditions Table 4 summarizes the standard requirements for unit size, spacing and setbacks as outlined in these regulations and statutes.

5.3 Drilling and Completion Statistics

Drilling practices in Kentucky vary by area and in some cases by reservoir. The majority of drilling operations in Kentucky are standard vertical tests. In eastern Kentucky and central and south-central Kentucky these tests are drilled with air rotary equipment while in the western Kentucky region mud rotary drilling is commonly utilized were water production is encountered (Combs, M., 2008). In some areas of western Kentucky were water production is not encountered air rotary methods can and are utilized. The average drilling depths in the eastern region range from 1,000 to 3,000 feet with deeper tests being in the range of 3,500 to 5,000 feet (Combs, M., 2008 and Bender, R., 2008). The average drilling depth in central and south-central Kentucky is generally less than 1,000 feet, but can range from 1,000 to 3000 feet. In western Kentucky drilling depths generally range from 1,000 feet to 3,000 feet with deeper tests in the range of 3,800 to more than 4,000 feet (Combs, M., 2008 and Bender, R. 2008).

While vertical drilling is still the standard for most operators in Kentucky, drilling for Devonian Shale gas resources in eastern and western Kentucky has in some cases been converting to horizontal drilling methods. Recently some of those horizontal wells have included multi-lateral horizontal segments (Combs, M., 2008 and Bender, 2008).

Completion practices for the Devonian Shale in eastern Kentucky have always included fracture treatments. Operators have gone from foam fracture treatments to nitrogen fracture treatment and are currently utilizing slick water fracture treatment procedures. Other completions generally rely on acid treatment for stimulation prior to placing the well into production (Combs, M., 2008).

5.3.1 Drilling Costs

Drilling costs and well completion costs in Kentucky vary by area which in turn varies by depth, reservoir, and completion practice for the specific reservoir to be produced. Generally well costs (drilling and completion) for the major producing areas in Kentucky are outlined in Table 5.

5.4 Production Statistics

Figures 11 and 12 plot the production of oil and gas by the region in the state of Kentucky. The oil production curve shows peak production around 1982 with steady declines since that year for each region. The lone exception to that general trend is 1993 from the eastern region of the state as shown in Figure 11. From a high point in 1993, gas rates declined the next year and have shown a gradual increase from 1994 to present day. Natural gas production is predominantly from the eastern region of the state.

Table 4: Summary of Well Spacing Requirements

Well Type	**Well Depth**	**Minimum Distance to Nearest Well In Same Pool**	**Setback to Nearest Property Line**
		Shallow Wells*	
Oil (Non-coal Areas)	0 to 2,000 Ft.	No closer than 400 Ft	200 Ft.
Oil (Non-coal Areas)	>2,000 to Deep Well Depth.	No closer than 660 Ft	330 Ft.
Oil (Coal Area)	0 to Deep Well Depth	No closer than 660 Ft	330 Ft.
Gas	0 to Deep Well Depth	No closer than 1,000 Ft	500 Ft.
Well Type	**Well Depth**	**Unit Size**	
		Deep Wells **	
Gas	4,000 ft to 7,000 Ft.	Locate in the center of a 281 acre square unit with sides of 3,500'	
Gas	> 7,000 Ft.	Locate in the center of a 574acre square unit with sides of 5,000'	
Oil	4,000 ft to 7,000 Ft.	Locate in the center of a 70 acre square unit with sides of 1,750'	
Oil	> 7,000 Ft.	Located in the center of a 143 acre square unit with sides of 2,500'	

* Shallow wells are wells drilled to depths less than 4,000' or where the base of the Devonian Shale exceeds 4,000' in Eastern Kentucky.

** A deep well is any well drilled to a depth that exceeds 4000' or to the base of the Devonian Black Shale in Eastern Kentucky if the base of the black shale exceeds 4000'. Unit sizes for deep wells are established by the Division of Oil and Gas after a "wildcat" well has discovered a productive formation or multiple formations. A "wildcat" well is defined as a well in which there are no other deep wells of the same target formation within 25,000' of the permitted location. Once a wildcat well has found a discovery and the KDOG has ordered the unit size, then other deep wells within 25,000' which target the same formation must be on approved units which are also established by the KDOGC. If an operator wishes to permit a well that is within 25,000' of wells on established spacing, and the proposed location is not on an approved unit, then the spacing shall be set as outlined above.

Source: Kentucky Division of Oil and Gas Conservation

5.4.1 Crude Oil

Annual crude oil production data for Kentucky for the period 1980 through 2006 is graphically displayed with pricing information in Figure 13. As can be seen from a review of this graph the annual crude oil production rate at the beginning of this period stood at 3,602,00 barrels of oil per year. That rate has subsequently declined to 2,340,000 barrels / year in 2006. This production decline trend is not expected to be significantly altered as most of the oil production located in the primary oil producing areas of western Kentucky and south-central Kentucky are categorized as mature to very mature production that is dependent on infill and trend development drilling and secondary recovery operations for sustaining this rate (Combs, M., 2008).

5.4.2 Natural Gas

Annual natural gas production in Kentucky for the years 1980 through 2006 is graphically displayed with pricing information in Figure 14. Natural gas production has generally been on the rise since 1999 when annual production stood at 81,869,121 Mcf of gas for the year. Since that year annual production has risen each year through which there is data available with 2006 annual production reaching 95,319,608 Mcf or a 16.4% increase in production over that which was reported in 1999. This increase in production is undoubtedly because of the significant increase in wellhead gas prices over that period coupled with the increase in drilling operations associated with the Devonian Shale gas play in Eastern Kentucky (Combs, M., 2008). Continued development of the Devonian Shale gas resource in both eastern and western Kentucky as well as additional exploratory drilling for Trenton-Black River reserves is also expected to maintain or increase gas production (Combs, M., 2008 and Bender, R. 2008.

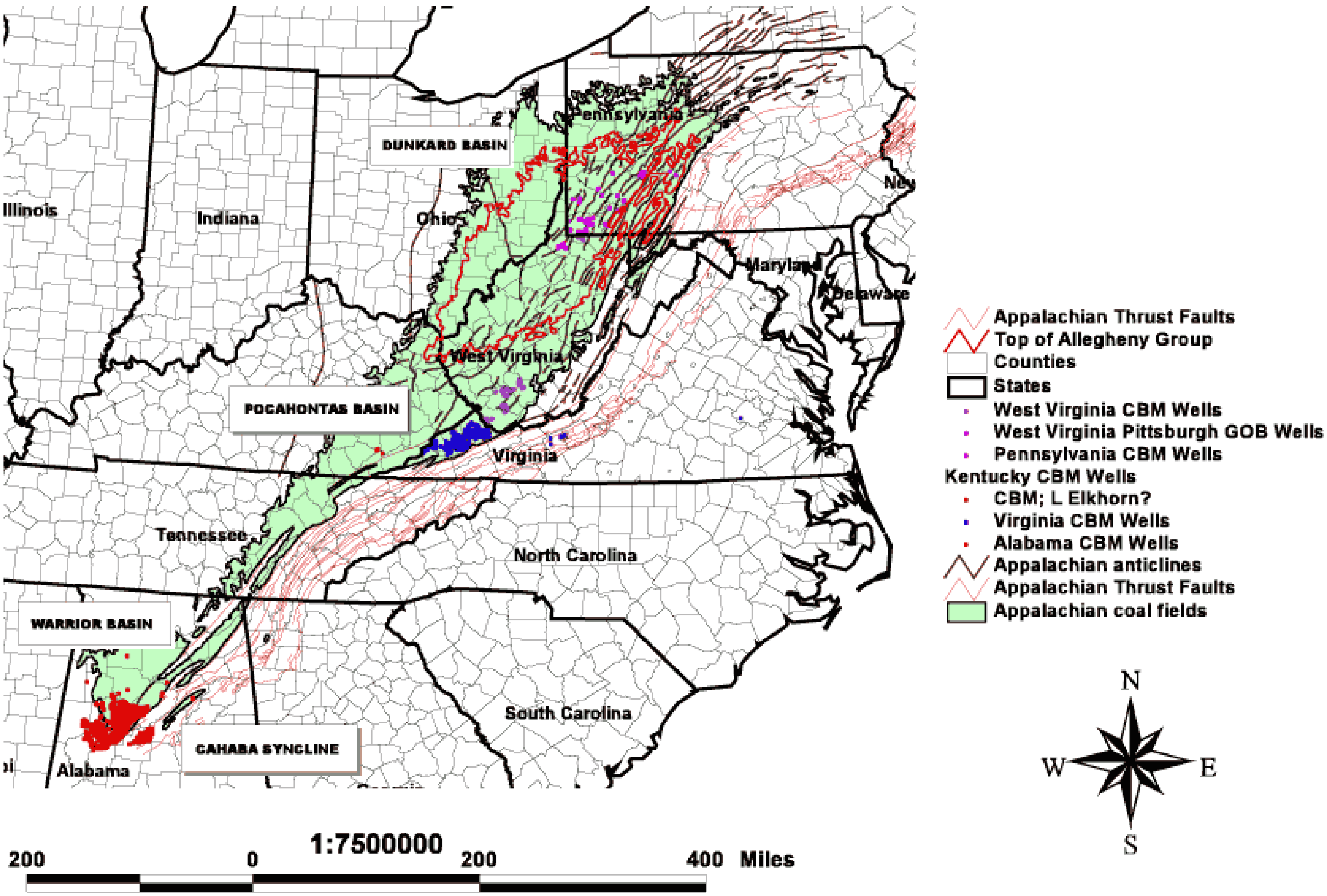
CBNG drilling will likely increase in the coming years as technology improves and natural gas prices stay high. Figure 10 indicates those counties in Eastern Kentucky that are most prospective for CBNG. At the same time, Western Kentucky includes part of the Moorman Rift Zone and part of the Illinois Basin that also hold prospective sections of Pennsylvanian age coals. Very few CBNG wells have been permitted in Kentucky up through 2007 but more are expected in the eastern and western portions of the state.

Table 5: Well Costs for Kentucky Producing Regions

Area	Type Well	Dry Hole Cost	Comp. Costs	Total Cost
Eastern Kentucky	Devonian Shale Gas Vertical Test	$180,000	$120,000	$300,000
Central Kentucky	Conventional Reservoir Vertical Test	$60, 000 to $70,000	$50,000	$110,000 to $120,000
Western Kentucky	Devonian Shale Reservoir Vertical Test	$80,000 to $100,000	$100,000	$180,000 to $200,000

Source: (Combs, M., 2008 and Bender, R. 2008)

Figure 10: CBNG in Kentucky and Surrounding States



Source: USGS, 2002

Figure 11: Crude Oil Production in Kentucky by Region 1980-2006

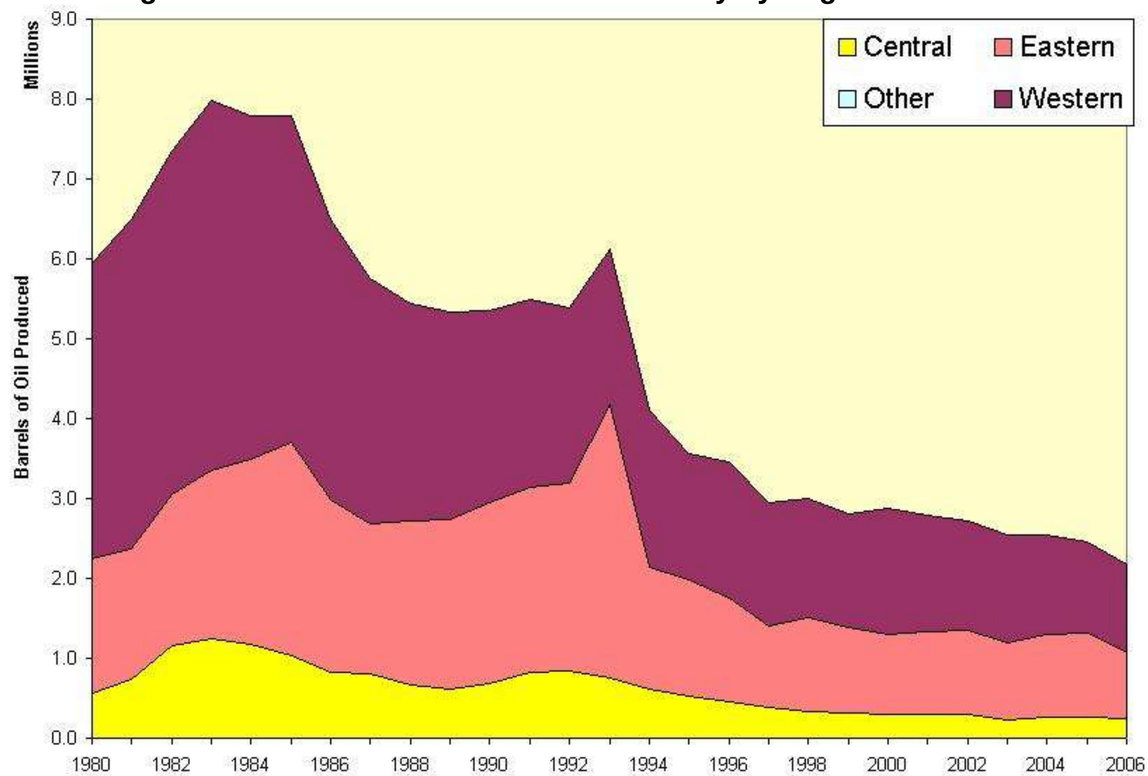


Figure 12: Natural Gas Production in Kentucky by Region 1980-2006

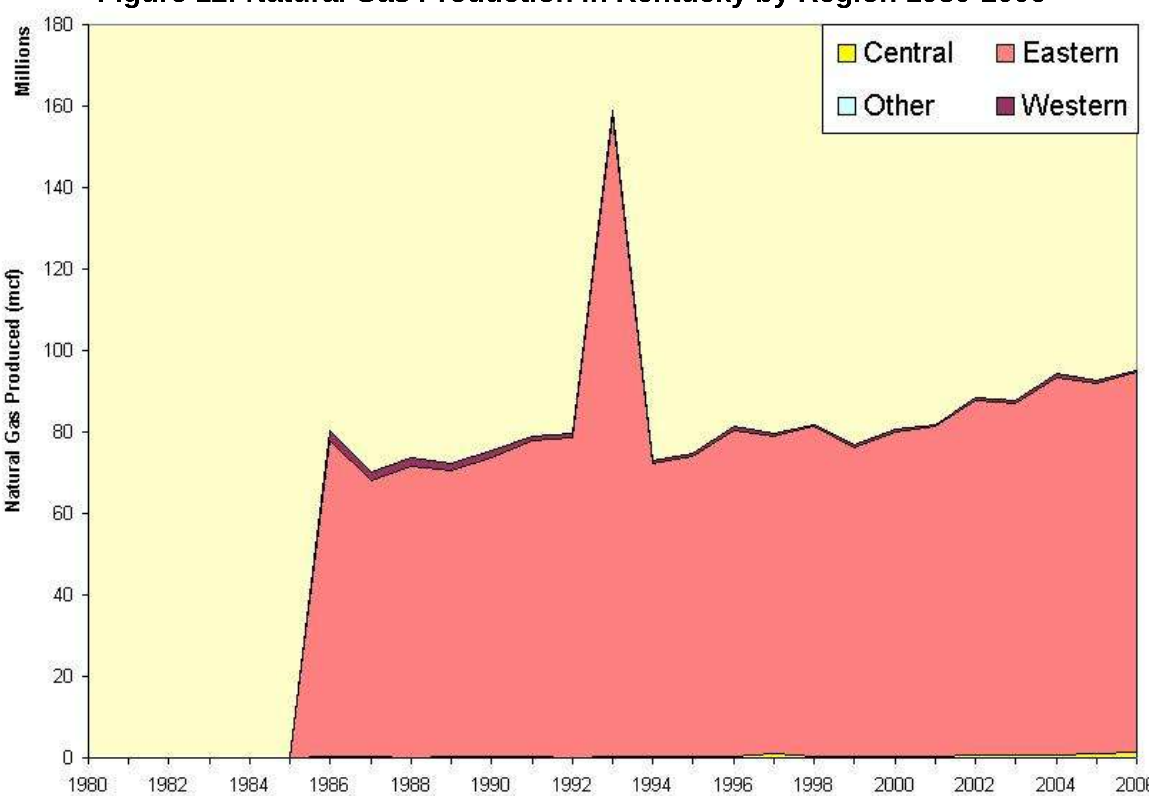


Figure 13: Annual Crude Oil Production in Kentucky with Price 1980-2006

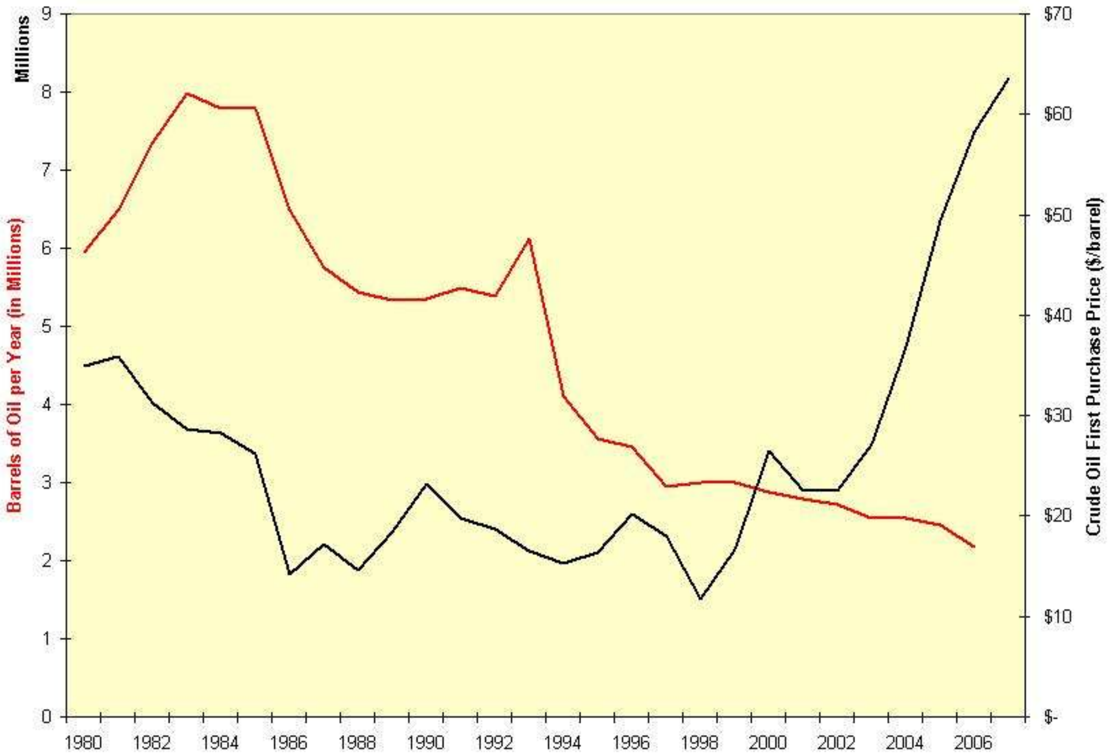
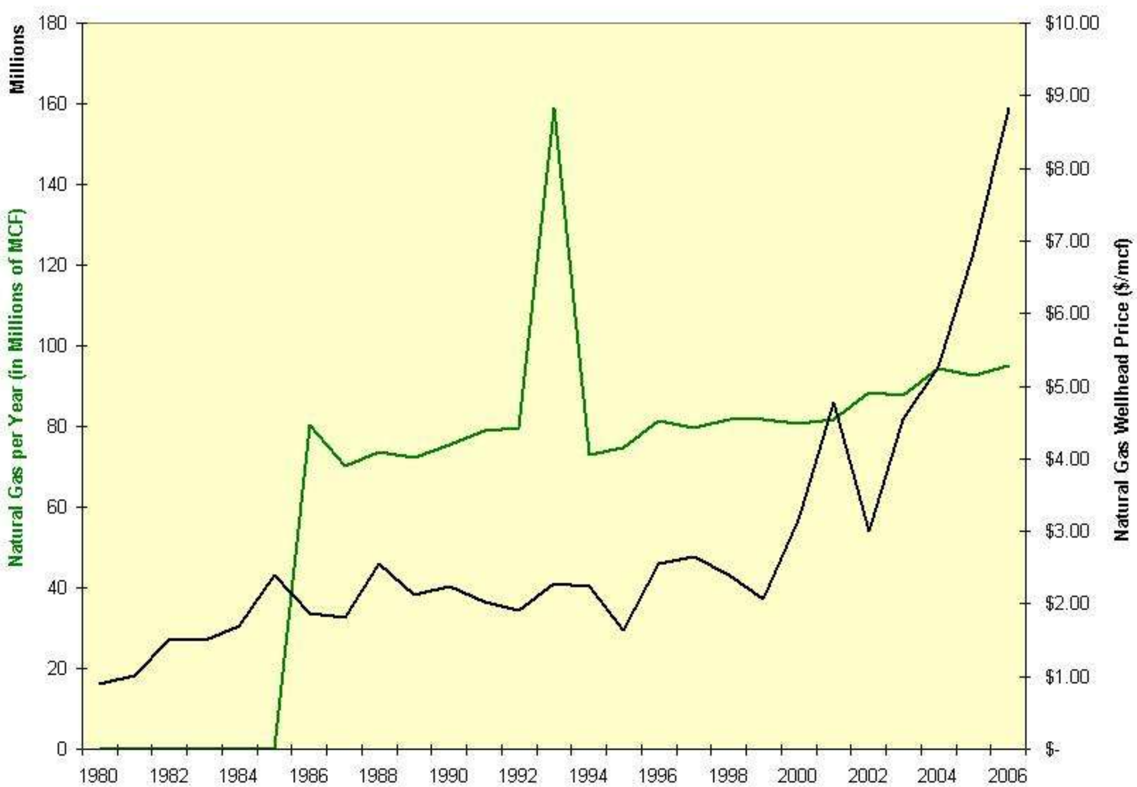


Figure 14: Annual Natural Gas Production in Kentucky with Price 1980-2006



5.5 Oil and Natural Gas Characteristics

5.5.1 Natural Gas

Little public information is available concerning the specific characteristics of natural gas produced in Kentucky. Natural gas produced from Devonian Shale reservoirs in eastern Kentucky is considered to be of good quality and is reported to be greater than 90% methane, with average Btu ratings in excess of 1,000 Btu's and no problems associated with CO_2 or nitrogen content (Combs, M., 2008). Unconventional gas from the New Albany Shale interval in western Kentucky has however been reported to contain nitrogen in quantities that require gas stripping operations, although not all of the gas from the New Albany Shale requires such treatment. Studies have suggested that shale gas requiring such treatment may be of thermo-genetic origin while shale gas of bio-genetic origin may not require such treatment (Nutall, B., 2008).

5.5.2 Crude Oil

Crude oil produced in Kentucky varies by depth, producing reservoir and region. Kentucky has a wide variety of API gravity ratings. Mississippian age reservoirs of western Kentucky generally have API gravity ratings of approximately 30˚, while the various reservoirs of central and south central area average 36˚ to 37˚. The Corniferous oil reservoirs of Eastern Kentucky generally contain higher gravity crude oils with API gravity approaching 40˚ (Combs, M., 2008).

5.6 Oil and Gas Prices

Average annual crude oil prices for Kentucky based on data from the Energy Information Agency (EIA) during the period from 1980 through 2006, as seen in Figure 13 referenced above in the section concerning production trends, show that crude oil prices have risen from $20.24 /bbl to $58.33/bbl (EIA, website, Kentucky Crude Oil Wellhead Acquisition Price by First Purchasers, 2007).

Annualized data for 2007 is not available , but the October 2007 posting of the average crude oil purchase price reported to EIA shows wellhead crude prices at 85.06 $/bbl for Kentucky (EIA, website, Kentucky Crude Oil Wellhead Acquisition Price by First Purchasers, 2007).

As can be seen from a review of the graph in Figure 14 the annual average wellhead price for Kentucky natural gas reported by the EIA has steadily risen from $2.07 /Mcf in 1999 to $8.83 /Mcf in 2006 (EIA website, 2007). Annualized data for 2007 is not as of yet available, current wellhead prices are estimated to be at or above NYMEX postings which are in the order of $7.25 /Mcf (Bender, R. 2007).

Both crude oil and natural gas prices are generally expected to remain strong for the foreseeable future.

5.7 Conflicts with Other Mineral Development

Mineral development in Kentucky is extensive and involves in addition to oil and gas a number of different mineral resources. They include: Coal, Tar Sands, Limestone and Dolomite, Clay Minerals, Sand and Gravel, and Other Mineral Deposits. Information contain in this mineral summary is from Tennessee Division of Geology Mineral and Fuel Resources Map (Anderson, Warren H., and Dever Jr., Garland R., 2001).

<u>Coal</u>

Mineable coal occurs in both Eastern Kentucky (Appalachian Basin) and Western Kentucky (Illinois Basin).

<u>Tar Sands</u>

Tar Sand Deposits are located in Western Kentucky (Illinois Basin).

<u>Limestone and Dolomite</u>

Limestone and dolomite is produced in Kentucky for use as construction aggregate, lime cement, and agricultural lime.

Clay Minerals

Clay minerals produced in Kentucky include common clay, ceramic clay, “Ball clay, refractory clay and shale.

Sand and Gravel

Sand and gravel are mined in Kentucky primarily as construction material and aggregate. Tar sand deposits have in the past been exploited as road aggregate.

Figure 15 is a map of the mineral and fuel resources of Kentucky prepared by the Kentucky Geological Survey (KGS). The map shows the location of those mineral deposits / mining operations relative to the areas of oil and natural gas resources.

There have in the past been some conflicts between oil and gas drilling operation and coal operations. Under the Kentucky oil and gas regulatory program all applications for drilling permits must identify if the proposed well is underlain by coal seams leased to, or currently being mined by an individual or company. If that is the case the well operator must send a copy of the permit application and well plat to the company or companies operating those seams. If the coal company objects to the location, the Kentucky Division of Oil and Gas will schedule a hearing. Based on information presented, the well location will be approved or moved to an alternate location as near to the original location as possible (Combs, M., 2008).

5.8 Gas Storage Fields

EIA gas storage data for 2006 indicates that there are 23 active gas storage field operating in the Commonwealth of Kentucky (EIA website, Natural Gas Storage, Form EIA-191 Data, 2007). The fields consist of both aquifer storage and storage in depleted gas fields that have been converted to gas storage operations. Details with respect to the operator, field name, location, reservoir, total field capacity, and authorized maximum daily delivery for those fields are provided in Table 6.

Figure 15: Mineral and Fuel Resources of Kentucky

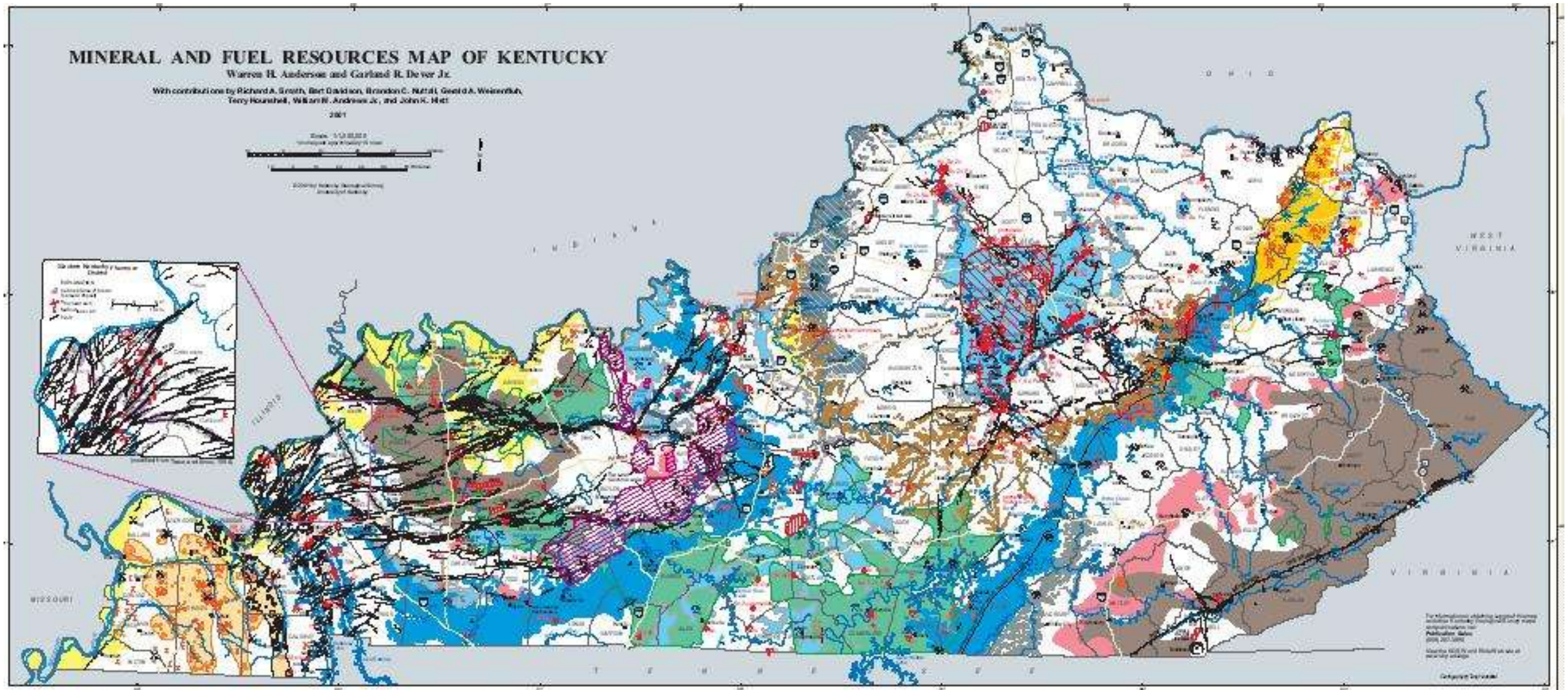


Table 6: Active Gas Storage Fields In Kentucky

Operator	Field Name	Location	Reservoir	Field Type	Total Field Capacity (Mcf) (2006)	Maximum Daily Delivery (Mcf) (2006)
Alcan Aluminum Corporation	East Slaughters		Pennsylvania	Aquifer	767,000	3,000
Atmos Energy Corporation	East Diamond	Hopkins Co.	Bethel Sandstone	Depleted Field	3,800,000	40,000
Atmos Energy Corporation	St Charles	Hopkins Co	Mississippian	Depleted Field	6,107,478	44,600
Atmos Energy Corporation	Hawesville N W		Mississippian	Depleted Field	93,656	
Atmos Energy Corporation	Grandview	Daviess Co.	Mississippian	Depleted Field	655,400	4,500
Atmos Energy Corporation	Bon Harbor	Daviess Co.	Mississippian	Depleted Field	2,078,600	24,000
Atmos Energy Corporation	Hickory	Daviess Co.	Mississippian	Depleted Field	1,301,600	24,000
Atmos Energy Corporation	Crofton East	Christian Co.	Mississippian	Depleted Field	105,000	
Atmos Energy Corporation	Kirkwood	Hopkins Co.	Mississippian	Depleted Field	650,000	12,000
Delta Natural Gas Company Inc	Kettle Island	Bell Co.	Pioneer Wells # 1,2,4 & 6	Depleted Field	1,406,000	2,000
Delta Natural Gas Company Inc	Canada Mountain	Bell Co.		Depleted Field	4,800,000	30,500
Elizabethtown Natural Gas	Cecilia Storage Field	Hardin Co.	Lego/Laurel	Aquifer	3,000,000	10,000
Louisville Gas And Electric Company	Center	Metcalfe Co.	Center	Depleted Field	5,100,000	40,000
Louisville Gas And Electric Company	Muldraugh	Meade Co.	Muldraugh	Depleted Field	4,600,000	220,000
Louisville Gas And Electric Company	Magnolia Upper	Hart Co.	Magnolia Upper	Depleted Field	6,000,000	74,000
Louisville Gas And Electric Company	Magnolia Deep	Hart Co.	Magnolia Deep	Depleted Field	4,400,000	42,000
Louisville Gas And Electric Company	Doe Run	Meade Co.	Doe Run	Aquifer	5,800,000	55,000
Texas Gas Transmission Corporation	Midland	Mulenburg Co.	Bethel	Depleted Field	133,141,878	882,500
Texas Gas Transmission Corporation	West Greenville	Mulenburg Co.	Bethel	Depleted Field	7,650,204	93,842
Texas Gas Transmission Corporation	Graham Lake	Mulenburg Co.	Tar Springs	Depleted Field	4,284,114	15,300
Texas Gas Transmission Corporation	Hanson	Hopkins Co.	Tar Springs	Depleted Field	12,087,322	71,402
Texas Gas Transmission Corporation	Dixie	Henderson Co.	Aberdeen	Depleted Field	7,687,000	101,493
UCG Storage	Barnsley	Hopkins Co.	Bethel	Depleted Field	2,878,900	30,000

6.0 OIL AND GAS OCCURRENCE POTENTIAL

6.1 Existing oil and gas production

Oil and gas has been produced in Kentucky since the 1850's. Thirty counties in the eastern region of Kentucky have had oil production, and twenty-six counties in the eastern region of Kentucky have had natural gas production. Twenty-five counties in the central region of Kentucky have had oil production, and fifteen counties in the central region of Kentucky have had natural gas production. Seventeen counties in the western region of Kentucky have had oil production, and thirteen counties in the western region of Kentucky have had natural gas production.

Table 7: Ranking of Counties in Kentucky by Cumulative Oil Production

Eastern		Central		Western	
County	**Cum Oil (bbls)**	**County**	**Cum Oil (bbls)**	**County**	**Cum Oil (bbls)**
Henderson	111,131,996.60	Lee	86,664,548.33	Green	17,059,896.26
Union	85,191,959.54	Magoffin	36,226,549.76	Warren	11,670,043.76
Daviess	56,128,051.93	Johnson	22,322,703.45	Allen	8,923,169.21
Ohio	50,217,168.39	Lawrence	18,396,942.66	Clinton	8,004,600.80
Webster	36,253,591.63	Estill	17,884,529.50	Hart	7,925,433.98
Mclean	34,298,263.64	Leslie	11,536,899.75	Barren	4,294,175.47
Hopkins	20,931,295.13	Powell	8,154,231.05	Cumberland	4,123,162.65
Muhlenberg	20,819,971.88	Letcher	7,129,755.77	Adair	3,963,813.14
Christian	13,570,675.70	Perry	6,857,008.60	Taylor	3,272,970.93
Hancock	10,581,325.65	Wolfe	4,202,931.10	Wayne	3,006,977.36
Butler	4,871,220.22	Elliott	2,619,560.30	Metcalfe	2,957,799.77
Breckinridge	1,164,804.23	Pike	2,288,950.79	Monroe	914,375.00
Todd	347,393.64	Breathitt	2,283,890.75	Edmonson	660,506.45
Logan	197,787.75	Martin	1,672,456.98	Russell	546,423.97
Crittenden	17,125.20	Floyd	1,571,323.62	Simpson	509,505.80
Caldwell	16,696.54	Knott	1,125,605.42	Bath	340,574.86
Grayson	5,757.64	Whitley	611,339.96	Pulaski	257,933.53
Livingston		Clay	512,551.55	Casey	242,065.09
Lyon		Menifee	386,318.73	Lincoln	196,426.49
Trigg		Mccreary	342,348.39	Hardin	63,513.75
		Morgan	337,448.77	Marion	2,374.36
		Harlan	296,438.19	Meade	2,021.03
		Bell	291,918.30	Anderson	816.61
		Knox	215,939.50	Boyle	654.09
		Greenup	209,882.67	Montgomery	355.59
		Jackson	205,486.70	Madison	150.00
		Owsley	189,084.06	Robertson	81.66
		Boyd	75,159.05	Spencer	70.06
		Laurel	54,172.92	Garrard	51.48
		Carter	1,843.32		
		Rowan	318.45		

Table 7 presents the ranking of Kentucky counties by region and by cumulative oil production. Table 8 presents the ranking of Kentucky counties by region and by cumulative gas production. Tables 9, 10, and 11 rank counties in each region by 2007 drilling; it is this last ranking that will be used to forecast drilling for the next ten years. Table 12 identifies the dryhole percentages by region for the recent past 2000-2007. Figures 16 and 17 depict the county rankings for oil and gas respectively.

Table 8 Ranking of Counties in Kentucky by Cumulative Gas Production

Eastern		Central		Western	
County	Cum Oil (bbls)	County	Cum Oil (bbls)	County	Cum Oil (bbls)
Pike	580,302,755.07	Meade	4,334,404.10	Hopkins	8,708,073.43
Floyd	229,640,377.75	Warren	1,657,293.78	Grayson	5,635,626.00
Knott	205,309,605.21	Pulaski	987,060.23	Muhlenberg	2,858,994.08
Martin	130,441,817.60	Fleming	684,823.00	Christian	1,853,858.00
Perry	122,347,100.67	Clark	659,436.40	Henderson	1,161,804.00
Letcher	78,718,077.96	Metcalfe	656,454.80	Mclean	679,448.00
Leslie	62,056,081.70	Edmonson	547,051.00	Logan	452,483.90
Clay	59,634,326.15	Campbell	391,356.21	Butler	385,622.00
Whitley	54,397,031.43	Barren	251,658.99	Ohio	361,913.21
Knox	38,403,202.05	Hardin	61,798.00	Webster	76,995.65
Johnson	22,926,068.33	Fayette	37,834.80	Breckinridge	63,636.00
Lawrence	20,171,603.44	Casey	19,600.00	Daviess	48,937.00
Magoffin	17,368,708.73	Gallatin	3,122.00	Trigg	15,228.28
Bell	14,803,004.94	Wayne	309.00		
Breathitt	13,670,675.28	Harrison	138.00		
Harlan	9,351,894.58				
Boyd	4,470,340.29				
Elliott	2,919,940.00				
Mccreary	1,541,991.93				
Laurel	1,474,251.97				
Morgan	854,909.08				
Greenup	612,764.91				
Jackson	448,423.20				
Wolfe	409,333.20				
Owsley	333,373.80				

Table 9: Eastern Kentucky Counties Ranked by 2007 Drilling

East KY Oil Ranking 2007 Drilling

County	Rank	Oil Wells	Dry Oil Tests
Bell	Very Low Oil	0	0
Boyd		0	0
Carter		0	0
Clay		0	0
Elliott		0	0
Estill		0	0
Floyd		0	0
Greenup		0	0
Harlan		0	0
Jackson		0	0
Johnson		0	0
Knott		0	0
Knox		0	0
Laurel		0	0
Lawrence		0	0
Letcher		0	0
Lewis		0	0
Martin		0	0
Mccreary		0	0
Menifee		0	0
Morgan		0	0
Owsley		0	0
Perry		0	0
Pike		0	0
Powell		0	0
Rockcastle		0	0
Rowan		0	0
Wolfe		0	0
Breathitt	Low Oil	1	0
Leslie		1	0
Magoffin		1	0
Whitley		1	0
Lee		2	0
Total		**6**	**0**

East KY Gas Ranking 2007 Drilling

County	Rank	Gas Wells	Dry Gas Tests
Boyd	Very Low Gas	0	0
Carter		0	0
Estill		0	0
Greenup		0	0
Jackson		0	0
Laurel		0	0
Lewis		0	0
Mccreary		0	0
Menifee		0	0
Owsley		0	0
Powell		0	0
Rockcastle		0	0
Rowan		0	0
Wolfe		0	0
Elliott	Low Gas	1	0
Lee		3	0
Morgan		3	0
Lawrence	Med Gas	6	0
Whitley		6	0
Breathitt		9	0
Clay		9	0
Johnson		10	0
Harlan		11	0
Martin		11	0
Bell		13	0
Magoffin		15	0
Floyd	High Gas	19	0
Knox		21	0
Knott		24	0
Perry		26	0
Pike		27	0
Leslie		44	0
Letcher		53	0
Total		**311**	**0**

Table 10: Central Kentucky Counties Ranked by 2007 Drilling

Central KY Oil Ranking 2007 Drilling			
County	**Rank**	**Oil Wells**	**Dry Oil Tests**
Meade	Very Low Oil	0	0
Pulaski		0	0
Bath		0	0
Edmonson		0	0
Hardin		0	0
Hart		0	0
Clark		0	0
Casey		0	0
Wayne		0	0
Anderson		0	0
Boone		0	0
Bourbon		0	0
Boyle		0	0
Bracken		0	0
Bullitt		0	0
Campbell		0	0
Carroll		0	0
Fayette		0	0
Fleming		0	0
Franklin		0	0
Gallatin		0	0
Garrard		0	0
Grant		0	0
Harrison		0	0
Henry		0	0
Jefferson		0	0
Jessamine		0	0
Kenton		0	0
Larue		0	0
Lincoln		0	0
Madison		0	0
Marion		0	0
Mason		0	0
Mercer		0	0
Montgomery		0	0
Nelson		0	0
Nicholas		0	0
Oldham		0	0
Owen		0	0
Pendleton		0	0
Robertson		0	0
Scott		0	0
Shelby		0	0
Simpson		0	0
Spencer		0	0
Trimble		0	0
Washington		0	0
Woodford		0	0
Monroe	Low Oil	1	0
Allen		1	0
Russell		2	1
Barren		3	0
Warren		4	0
Cumberland		6	0
Taylor		7	0
Clinton		8	1
Adair		9	0
Green	Med Oil	20	0
Metcalfe		22	0
Total		**83**	**2**

Central KY Gas Ranking 2007 Drilling			
County	**Rank**	**Gas Wells**	**Dry Gas Tests**
Adair	Very Low Gas	0	0
Green		0	0
Clinton		0	0
Taylor		0	0
Barren		0	0
Russell		0	0
Meade		0	0
Monroe		0	0
Allen		0	0
Pulaski		0	0
Bath		0	0
Hardin		0	0
Hart		0	0
Casey		0	0
Wayne		0	0
Anderson		0	0
Boone		0	0
Bourbon		0	0
Boyle		0	0
Bracken		0	0
Bullitt		0	0
Campbell		0	0
Carroll		0	0
Fayette		0	0
Fleming		0	0
Franklin		0	0
Gallatin		0	0
Garrard		0	0
Grant		0	0
Harrison		0	0
Henry		0	0
Jefferson		0	0
Jessamine		0	0
Kenton		0	0
Larue		0	0
Lincoln		0	0
Madison		0	0
Marion		0	0
Mason		0	0
Mercer		0	0
Montgomery		0	0
Nelson		0	0
Nicholas		0	0
Oldham		0	0
Owen		0	0
Pendleton		0	0
Robertson		0	0
Scott		0	0
Shelby		0	0
Simpson		0	0
Spencer		0	0
Trimble		0	0
Washington		0	0
Woodford		0	0
Cumberland	Low Gas	1	0
Edmonson		1	0
Clark		1	0
Metcalfe		2	0
Warren		4	0
Total		**9**	**0**

Table 11: Western Kentucky Counties Ranked by 2007 Drilling

Western KY Oil Ranking 2007 Drilling					Western KY Gas Ranking 2007 Drilling			
County	Rank	Oil Wells	Dry Oil Tests		County	Rank	Gas Wells	Dry Gas Tests
Breckinridge	Very Low Oil	0	0		Breckinridge	Very Low Gas	0	0
Butler		0	0		Butler		0	0
Caldwell		0	0		Caldwell		0	0
Christian		0	0		Crittenden		0	0
Crittenden		0	0		Daviess		0	0
Daviess		0	0		Grayson		0	0
Grayson		0	0		Hancock		0	0
Hopkins		0	0		Henderson		0	0
Livingston		0	0		Livingston		0	0
Logan		0	0		Logan		0	0
Lyon		0	0		Mclean		0	0
Mclean		0	0		Muhlenberg		0	0
Ohio		0	0		Ohio		0	0
Todd		0	0		Todd		0	0
Trigg		0	0		Trigg		0	0
Union		0	0		Union		0	0
Hancock	Low Oil	1	0		Christian	Low Gas	1	0
Henderson		1	0		Lyon		1	0
Muhlenberg		1	0		Webster		1	0
Webster		1	0		Hopkins		2	0
Total		**4**	**0**		**Total**		**5**	**0**

Table 12: Dryhole Percentage by Region

Kentucky Oil and Gas Drilling: Dryhole Percent by Region									
Region	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**Average**
Central	51.24%	35.27%	64.74%	44.30%	44.71%	41.39%	31.97%	7.19%	**40.10%**
Eastern	2.65%	3.77%	3.82%	1.26%	1.58%	1.07%	0.97%	0.09%	**1.90%**
Western	47.57%	42.67%	42.74%	51.40%	47.13%	34.84%	18.18%	12.00%	**37.07%**

Figure 16: Map of Kentucky with Oil Rankings

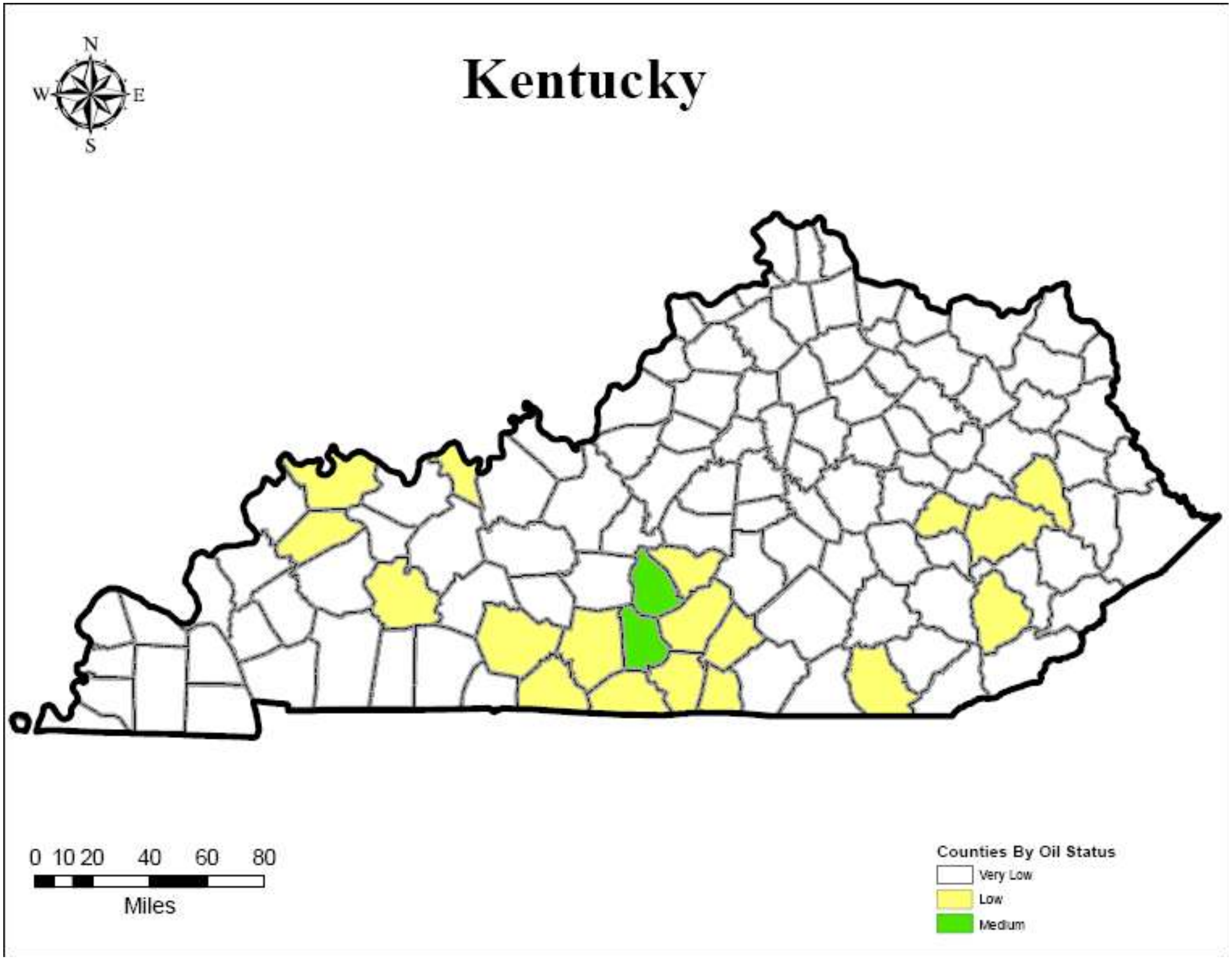
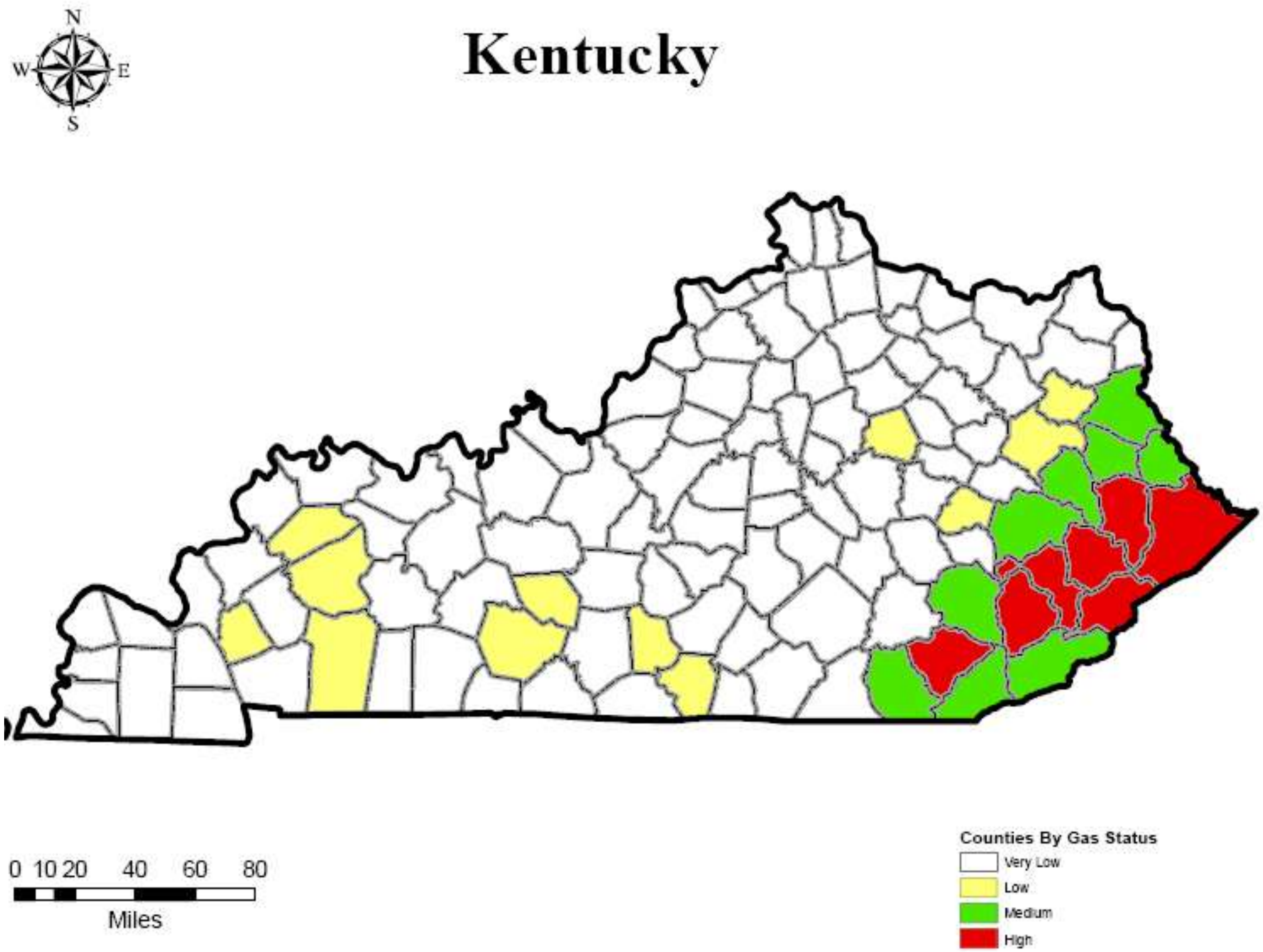


Figure 17: Map of Kentucky with Gas Rankings



7.0 OIL AND GAS DEVELOPMENT POTENTIAL

7.1 Relative Oil and Gas Development Potential

Counties are ranked in the previous section according to current production and drilling activity. Many counties have seen increased natural gas activity since approximately 1999, driven by increases in product price. It is expected that the current historical high price for oil (between $100 and $120 per bbl) will continue into the future or increase to some extent. If, on the other hand, crude oil prices were to slip downward, the price of natural gas would also be affected and drilling rates would likely be reduced.

It is expected that the counties labeled as high-rank will show continued development and continued drilling. Medium rank and low rank counties (Tables 9 to 11) are expected to see a small number of wells drilled each year but show little or no increase in the rate of drilling. It is expected that 930 oil wells, 3,250 gas wells, and 467 dry-holes will be drilled during the next ten years in the state.

The future potential for oil and gas can be estimated from current levels of activity for the various counties in Kentucky. It is best to rank the Eastern counties separate from the Central and Western counties as shown in the tables 9-11 and on figures 16 and 17.

7.1.1 Eastern Kentucky Region

The eastern region has produced a good portion of the state's oil and most of the state's natural gas. It has been the site of most of the state's drilling. It is expected that drilling activity across the region will be similar to 2007 in terms of number of wells, locations of the wells (located by county), drilling depth, and drilling methodology.

Drilling activity forecast is shown in Table 13; the forecast value for annual wells during the next ten years is extrapolated from drilling activity in 2007. The number of wells shown in Table 13 is split between general federal ownership, US Forest Service, and state plus fee land on the basis of the percentage of ownership in the county. Since we do not know where future drilling will happen within each county, we can assume a random distribution. The ten-year forecast is for a region-wide total of 3170 producing wells and 60 dry holes. On the other hand, several counties in the region are forecast to have no drilling during the next ten years.

7.1.2 Central Kentucky Region

The central region has historically produced little of the state's oil and natural gas. It has been the site of little drilling. It is expected that drilling activity across the region will be similar to 2007 in terms of number of wells, locations of the wells (located by county), drilling depth, and drilling methodology.

Drilling activity forecast is shown in Table 14 for annual wells per county during the next ten years as extrapolated from 2007 drilling statistics. The number of wells shown in Table 14 is split between general federal ownership, US Forest Service, and state plus fee land on the basis of the percentage of ownership in the county. Since we do not know where future drilling will happen within each county, we can assume a random distribution. The ten-year forecast is for a region-wide total of 920 producing wells and 368 dry holes. On the other hand, several counties in the region are forecast to have no drilling during the next ten years.

7.1.3 Western Kentucky Region

The central region has historically produced most of the state's oil but almost no natural gas. It has been the site of little drilling. It is expected that drilling activity across the region will be similar to 2007 in terms of number of wells, locations of the wells (located by county), drilling depth, and drilling methodology.

Drilling activity forecast is shown in Table 15 for annual wells per county during the next ten years as extrapolated from 2007 drilling statistics. The number of wells shown in Table 15 is split between general federal ownership, US Forest Service, and state plus fee land on the basis of the percentage

Table 13: Eastern Region Forecast Drilling

Eastern Kentucky 10-Year Forecast Oil Drilling

Eastern Kentucky 10-Year Forecast Oil Drilling				Federal Ownership		Forecast Federal Oil Wells			
County	Rank	Oil Wells	Dry Oil (2% average)	USFS %	Non-USFS Federal %	USFS Oil Wells	USFS Oil Dryholes	Non USFS Oil Wells	Non-USFS Oil Dryholes
Breathitt	**Low Oil**	10	0	0.1	0	0	0	0	0
Leslie		10	0	99.8	0	10	0	0	0
Magoffin		10	0	0	0	0	0	0	0
Whitley		10	0	21.1	0	2	0	0	0
Lee		20	0	56.2	0	11	0	0	0
Total		**60**	**0**			**23**	**0**	**0**	**0**

Eastern Kentucky 10-Year Forecast Gas Drilling

Eastern Kentucky 10-Year Forecast Gas Drilling				Federal Ownership		Forecast Federal Gas Wells			
County	Rank	Gas Wells	Dry Gas (2% average)	USFS %	Non-USFS Federal %	USFS Gas Wells	USFS Gas Dryholes	Non USFS Gas Wells	NonUSFS Gas Dryholes
Elliott	**Low Gas**	10	0	0	0.2	**0**	**0**	**0**	**0**
Lee		30	1	56.2	0	**17**	**1**	**0**	**0**
Morgan		30	1	10.9	0.5	**3**	**0**	**0**	**0**
Lawrence	**Med Gas**	60	1	0	0	**0**	**0**	**0**	**0**
Whitley		60	1	21.1	0	**13**	**0**	**0**	**0**
Breathitt		90	2	0.1	0	**0**	**0**	**0**	**0**
Clay		90	2	95.2	0	**86**	**2**	**0**	**0**
Johnson		100	2	0	0	**0**	**0**	**0**	**0**
Harlan		110	2	5.5	0.5	**6**	**0**	**1**	**0**
Martin		110	2	0	0	**0**	**0**	**0**	**0**
Bell		130	2	3	4.3	**4**	**0**	**6**	**0**
Magoffin		150	3	0	0	**0**	**0**	**0**	**0**
Floyd	**High Gas**	190	4	0	0.6	**0**	**0**	**1**	**0**
Knox		210	4	0.1	0	**0**	**0**	**0**	**0**
Knott		240	5	0	0.6	**0**	**0**	**1**	**0**
Perry		260	5	12.7	0	**33**	**1**	**0**	**0**
Pike		270	5	2.8	0.5	**8**	**0**	**1**	**0**
Leslie		440	8	99.8	0	**439**	**8**	**0**	**0**
Letcher		530	10	9.1	0	**48**	**1**	**0**	**0**
Total		**3110**	**60**			**657**	**13**	**10**	**0**

Note: All wells are considered to be shallow for purposes of estimating surface disturbance.

Table 14: Central Region Forecast Drilling

Central Kentucky 10-Year Forecast Oil Drilling

Central Kentucky 10-Year Forecast Oil Drilling				Federal Ownership		Forecast Federal Oil Wells			
County	**Rank**	**Oil Wells**	**Dry Oil (40% average)**	**USFS %**	**Non-USFS Federal %**	**USFS Oil Wells**	**USFS Oil Dryholes**	**Non USFS Oil Wells**	**Non-USFS Oil Dryholes**
Monroe	Low Oil	10	4	0	0	**0**	**0**	**0**	**0**
Allen	Low Oil	10	4	0	0	**0**	**0**	**0**	**0**
Russell	Low Oil	20	8	0	9.6	**0**	**0**	**2**	**1**
Barren	Low Oil	30	12	0	0.3	**0**	**0**	**0**	**0**
Warren	Low Oil	40	16	0	0	**0**	**0**	**0**	**0**
Cumberland	Low Oil	60	24	0	0.9	**0**	**0**	**1**	**0**
Taylor	Low Oil	70	28	0	0	**0**	**0**	**0**	**0**
Clinton	Low Oil	80	32	0	2.5	**0**	**0**	**2**	**1**
Adair	Low Oil	90	36	0	0	**0**	**0**	**0**	**0**
Green	Med Oil	200	80	0	0	**0**	**0**	**0**	**0**
Metcalfe	Med Oil	220	88	0	0	**0**	**0**	**0**	**0**
Total		**830**	**332**			**0**	**0**	**5**	**2**

Central Kentucky 10-Year Forecast Gas Drilling

Central Kentucky 10-Year Forecast Gas Drilling				Federal Ownership		Forecast Federal Gas Wells			
County	**Rank**	**Gas Wells**	**Dry Gas (40% average)**	**USFS %**	**Non-USFS Federal %**	**USFS Gas Wells**	**USFS Gas Dryholes**	**Non USFS Gas Wells**	**Non-USFS Gas Dryholes**
Cumberland	Low Gas	10	4	0	0.9	**0**	**0**	**0**	**0**
Edmonson	Low Gas	10	4	0	22.4	**0**	**0**	**2**	**1**
Clark	Low Gas	10	4	0	0	**0**	**0**	**0**	**0**
Metcalfe	Low Gas	20	8	0	0	**0**	**0**	**0**	**0**
Warren	Low Gas	40	16	0	0	**0**	**0**	**0**	**0**
Total		**90**	**36**			**0**	**0**	**2**	**1**

Note: All wells are considered to be shallow for purposes of estimating surface disturbance.

of ownership in the county. Since we do not know where future drilling will happen within each county, we can assume a random distribution. The ten-year forecast is for a region-wide total of 90 producing wells and 39 dry holes. On the other hand, several counties in the region are forecast to have no drilling during the next ten years.

7.2 Federal Drilling Forecasts

Table 16 summarizes the oil and gas activity predicted for Federal lands in Kentucky. US Forest Service lands can expect a large number of wells (697) to be drilled in the eastern portion of the state. Drilling on Federal lands in the other regions will be sparse. State and fee lands will see the bulk of activity with 3,479 wells forecast.

Table 15: Western Region Forecast Drilling

Western Kentucky 10-Year Forecast Oil Drilling

Western Kentucky 10-Year Forecast Oil Drilling				Federal Ownership		Forecast Federal Oil Wells			
County	Rank	Oil Wells	Dry Oil (37% average)	USFS %	Non-USFS Federal %	USFS Oil Wells	USFS Oil Dryholes	Non USFS Oil Wells	Non-USFS Oil Dryholes
Hancock	Low Oil	10	4	0	0	**0**	**0**	**0**	**0**
Henderson		10	4	0	0	**0**	**0**	**0**	**0**
Muhlenberg		10	4	0	0	**0**	**0**	**0**	**0**
Webster		10	4	0	0	**0**	**0**	**0**	**0**
Total		**40**	**16**			**0**	**0**	**0**	**0**

Western Kentucky 10-Year Forecast Gas Drilling

Western Kentucky 10-Year Forecast Gas Drilling				Federal Ownership		Forecast Federal Gas Wells			
County	Rank	Gas Wells	Dry Gas (37% average)	USFS %	Non-USFS Federal %	USFS Gas Wells	USFS Gas Dryholes	Non USFS Gas Wells	Non-USFS Gas Dryholes
Christian	Low Gas	10	4	0	2.9	**0**	**0**	**0**	**0**
Lyon		10	4	25.3	5.5	**3**	**1**	**1**	**0**
Webster		10	4	0	0	**0**	**0**	**0**	**0**
Hopkins		20	7	0	0	**0**	**0**	**0**	**0**
Total		**50**	**23**			**3**	**1**	**1**	**0**

Note: All wells are considered to be shallow for purposes of estimating surface disturbance.

Table 16: Federal Activity Forecast Ten-Year Forecast for Oil and Gas Wells in Kentucky

Region	Total Oil and Gas Wells	Total Dry-holes	USFS Oil and Gas Wells	USFS Dry-holes	Non-USFS Federal Oil and Gas Wells	Non-USFS Federal Dry-holes
Eastern	3170	60	680	13	10	0
Central	920	368	0	0	7	3
Western	90	39	3	1	1	0
State Total	**4180**	**467**	**683**	**14**	**18**	**3**

8.0 Reasonable Foreseeable Development Baseline Scenario Assumptions and Discussion

This RFD scenario assumes that all potentially productive areas are open under the standard lease terms and conditions except those areas designated as closed to leasing by law, regulation, or executive order. The areas closed to leasing typically include Areas of Critical Environmental Concern (ACECs), Wilderness Study Areas (WSAs) and USFWS Wildlife Refuges. Within the State of Kentucky there are two USFS Wilderness areas, two National Parks, one USFWS Wildlife refuge and no ACECs or WSAs that occur within the counties that have federal development potential. The RFD scenario contains projections for the number or wells and acres disturbed for these counties. This in no way is intended to imply that the BLM are making decisions about the Forest Service lands or the USFWS lands. The predictions are intended to provide the information necessary so that all potential cumulative impacts can be analyzed. The disturbance for each well is based on the typical depth of wells for an area; generally, shallow gas wells disturb fewer acres than deeper oil wells. The assumptions for conventional oil and gas are as follows:

The number of wells was calculated based on historical statistics and data trends as follows:

- Wells drilled to date were taken from the Kentucky Oil and Gas Commission's public database.
- The number of wells drilled to date was statistically analyzed to calculate a median per year wells drilled per county.
- The data trends associated with the last 7 years (2000-2007) represents a more accurate estimate of future development trends than historical data, thus, it is weighted more heavily.
- The data trends from 1992 to present data set are a more accurate estimate of future trends than the complete historical record and were weighted more heavily than the historical record.
- The data trends for the complete historical record represent the least accurate estimate of future development trends and, thus, it was weighted the lightest.
- For each geographic/geologic boundary region and sub region, the calculated estimates for future development were summed to obtain a per year well count.
- Wellhead oil and gas prices are a driving force for well drilling and completion; current prices are historically high and have resulted in increased activity throughout the state. An estimate of activity for the future well development to into consideration this influence. The forecast assumes wellhead oil and gas prices will remain high and development over the next ten years will continue at an elevated rate.
- Estimates of well counts for the different mineral ownership entities are based on spatial analysis of the percent of mineral ownership within each county times the total number of producing wells anticipated to be developed in that boundary area.
- The average acreage figure (acres per well) for the resource area was used to estimate federal disturbed acres.
- The RFD projections have a 10-year life.
- The number of dry holes was determined based on historic analysis of dry holes in the geologic boundary areas.

The assumptions were used to calculate the number of wells to be drilled, the number of in-field compressors, and the number of sales compressors required.

9.0 SURFACE DISTURBANCE DUE TO OIL AND GAS ACTIVITY ON ALL LANDS

9.1 Surface Disturbances

Estimates of the surface disturbances associated with the development of oil and gas on federal minerals within the State of Kentucky were determined from a variety of resources, including previous oil and gas environmental assessments, discussions with BLM and state oil and gas personnel, discussions with various operators, and document review.

The level of disturbance associated with conventional oil and gas development varies depending on the depth of the well and type of well drilled (horizontal vs. vertical). A shallow oil and gas well (<2,000 feet deep) typically includes a well pad of 2.0 acres, 0.10 miles of gravel road and 0.55 miles of utility lines for a total construction disturbance area of approximately 4.8 acres. Deeper oil and gas wells (5,000 to 12,000 feet below surface) require a greater disturbance area to accommodate the larger amount of equipment necessary to complete drilling. Usually a 3.25 acre well pad, 0.075 miles of gravel road, and 0.475 miles of utility lines for a total of 6.7 disturbed acres during the construction phase. Horizontal wells are typically drilled using a larger well pad estimated at 3.5 acres. However, the total construction disturbance for a horizontal oil and gas well is estimated to be 6.9 acres. This estimate is greater than the disturbance from deep oil and gas wells because the surface disturbance required for construction of both utility and transportation lines will be somewhat more for horizontal wells. Tables 17, 18, and 19 present surface disturbance estimates for conventional shallow and deep oil and gas wells and horizontal wells along with their associated support facilities. The data for surface disturbances from CBNG wells are presented in Table 20.

The surface disturbances are scaled to a per well disturbance level so that calculation of the total disturbance can be generated at the project, field, or county level by multiplying the number of wells for analysis by the numbers provided in the table. Existing surface disturbances are commensurate with the estimates provided in Tables 17, 18, 19, and 20.

9.2 Site Construction

The shortest feasible route is chosen to minimize haulage distances and construction costs while considering environmental factors and the surface owner's wishes. The access roads are typically constructed using bulldozers and graders to connect the existing road or trail and the drillsite. In some cases improvements such as cattle guards and culvert crossings are installed because of the terrain.

In the planning area the kind of drill rig and drilling depth varies and is determined by the geologic province and expected product from the well. The extent of surface disturbance necessary for construction depends on the terrain, depth of the well, drill rig size, circulating system, and safety standards. The depth of the drill test determines the size of the work area necessary, the need for all-weather roads, water requirements, and other needs. The terrain influences the construction problems and the amount of surface area to be disturbed. Reserve pit size may vary because of well depth, drill rig size, or circulating system.

Access roads to well sites usually consist of running surfaces 14 to 18 feet wide that are ditched on one or both sides. Many of the roads constructed will follow existing roads or trails. New roads might be necessary because existing roads are not at an acceptable standard. For example, a road may be too steep so that realignment is necessary.

Table 17: Level of Disturbance for Conventional Shallow Oil and Gas Wells and Associated Production Facilities

FACILITIES		Exploratory Well Disturbance (acres/well)	Construction Disturbance (acres/well)	Operation/ Production Disturbance (acres/well)
Well Pad (300-foot by 300-foot pad during drilling and construction, 175-foot by 175-foot pad during operation)		2.07	2.07	0.70
Access Roads to Well Sites	Two-track (12-foot wide by 0.25 miles long)	0.36	N/A	N/A
	Graveled (20-foot wide by 0.10 miles long for construction and operation)	N/A	N/A	0.24
	Bladed (20-foot wide by 0.10 miles for construction and operation)	N/A	0.24	0.0
Utility Lines	Water lines (15-foot by 0.20 miles)	N/A	0.18	0.0
	Overhead Elec. (10-foot by 0.15 miles)	N/A	0.12	0.03
	Underground Elec. (15-foot by 0.20 miles)	N/A	0.36	0.0
Transportation Lines	Intermediate Press. Gas line to and from field compressor (15-foot by 0.1 miles)	N/A	0.18	0.045
	High Press. Gas or Crude Oil Gathering Line (20-foot by 0.25 miles)	NA	0.61	0.15
Processing Areas	Tank Battery (one 0.50-ac tank battery per 20 wells)	N/A	0.025	0.025
	Access Roads (25-foot by 0.05 miles)	N/A	0.15	0.15
	Field Compressor (0.5-acre pad per 20 wells)	N/A	0.025	0.025
	Sales Compressor (2-ac pad for 150 wells)	N/A	0.01	0.01
	Sales Line (20-foot by 5 miles per 200 wells)	N/A	0.061	0.015
Produced Water Management	Produced Water pipeline (15-foot by 0.25 miles)	N/A	0.45	0.11
	Water plant/ Inj well (6 ac site per 20 wells)	N/A	0.3	0.3
Total Disturbance per Conventional Oil or Gas Well (acres)		**2.43**	**4.79**	**1.81**

1. The operation disturbance for utilities assumes all utilities will be completed underground, and the land surface will be reclaimed so that no disturbance should remain except where noted.
2. It is assumed that each conventional oil and gas well will need product pipeline and produced water line from the well. In addition, some wells will need intermediate pipeline run from the field compressor to sales line.

Table 18: Level of Disturbance for Conventional Deep Oil and Gas Wells and Associated Production Facilities

FACILITIES		Exploratory Well Disturbance (acres/well)	Construction Disturbance (acres/well)	Operation/ Production Disturbance (acres/well)
Well Pad (375-foot by 375-foot pad during drilling and construction, 200-foot by 200-foot pad during operation)		3.23	3.23	0.92
Access Roads to Well Sites	Two-track (12-foot wide by 0.5 miles long)	0.73	N/A	N/A
	Graveled (20-foot wide by 0.075 miles long for construction and operation)	N/A	N/A	0.18
	Bladed (20-foot wide by 0.075 miles for construction and operation)	N/A	0.18	N/A
Utility Lines	Water lines (12-foot by 0.20 miles)	N/A	0.29	0.0
	Overhead Elec. (10-foot by 0.075 miles)	N/A	0.09	0.023
	Underground Elec. (15-foot by 0.20 miles)	N/A	0.36	0.0
Transportation Lines	Intermediate Press. Gas line to and from field compressor (15-foot by 0.075 miles)	N/A	0.14	0.034
	High Press. Gas or Crude Oil Gathering Line (25-foot by 0.5 miles)	NA	1.21	0.30
Processing Areas	Tank Battery (one 0.50-ac tank battery per 15 wells)	N/A	0.03	0.03
	Access Roads (25-foot by 0.05 miles)	N/A	0.15	0.15
	Field Compressor (0.5-acre pad per 15 wells)	N/A	0.03	0.03
	Sales Compressor (2-ac pad for 150 wells)	N/A	0.01	0.01
	Sales Line (25-foot by 6 miles per 150 wells)	N/A	0.12	0.12
Produced Water Management	Produced Water pipeline (15-foot by 0.25 miles)	N/A	0.45	0.11
	Water plant/ Inj well (6 ac site per 15 wells)	N/A	0.40	0.40
Total Disturbance per Conventional Oil or Gas Well (acres)		**3.96**	**6.71**	**2.24**

1. The operation disturbance for utilities assumes all utilities will be completed underground, and the land surface will be reclaimed so that no disturbance should remain except where noted.
2. It is assumed that each conventional oil and gas well will need product pipeline and produced water line from the well. In addition, some wells will need intermediate pipeline run from the field compressor to sales line.

Table 19: Level of Disturbance for Horizontal Gas Wells and Associated Production Facilities

FACILITIES		Exploratory Well Disturbance (acres/well)	Construction Disturbance (acres/well)	Operation/ Production Disturbance (acres/well)
Well Pad (360-foot by 360-foot pad during drilling and construction, 200-foot by 200-foot pad during operation)		2.98	2.98	0.92
Access Roads to Well Sites	Two-track (15-foot wide by 0.25 miles long)	0.45	N/A	N/A
	Graveled (15-foot wide by 0.15 miles long for construction and operation)	N/A	0.0	0.27
	Bladed (15-foot wide by 0.15 miles for construction and operation)	N/A	0.27	0.0
Utility Lines	Water lines (15-foot by 0.5 miles)	N/A	0.90	0.0
	Overhead Elec. (10-foot by 0.15 miles)	N/A	0.18	0.045
	Underground Elec. (15-foot by 0.15 miles)	N/A	0.27	0.0
Transportation Lines	Intermediate Press. Gas line to and from field compressor (15-foot by 0.25 miles)	N/A	0.45	0.11
	High Press. Gas or Crude Oil Gathering Line (20-foot by 0.5 miles)	NA	1.21	0.30
Processing Areas	Tank Battery (one 0.50-ac tank battery per 16 wells)	N/A	0.031	0.031
	Access Roads (25-foot by 0.05 miles)	N/A	0.15	0.15
	Field Compressor (0.5-acre pad per 16 wells)	N/A	0.031	0.031
	Sales Compressor (2-ac pad for 128 wells)	N/A	0.016	0.016
	Sales Line (20-foot by 4 miles per 128 wells)	N/A	0.075	0.019
Produced Water Management	Discharge Point	N/A	N/A	N/A
	Storage Impoundment (20 acres each serving 64 wells)	N/A	0.31	0.31
Total Disturbance per Conventional Oil or Gas Well (acres)		**3.43**	**6.90**	**2.21**

1. The operation disturbance for utilities assumes all utilities will be completed underground, and the land surface will be reclaimed so that no disturbance should remain except where noted.
2. It is assumed that each conventional oil and gas well will need product pipeline and produced water line from the well. In addition, some wells will need intermediate pipeline run from the field compressor to sales line.

Table 20: Level of Disturbance for CBNG Wells and Associated Production Facilities

FACILITIES		Exploratory Well Disturbance (acres/well)	Construction Disturbance (acres/well)	Operation/ Production Disturbance (acres/well)
Well Pad (100-foot by 100-foot pad during drilling and construction, 200-foot by 200-foot pad during operation)		0.25	0.25	0.05
Access Roads/ Routes to Well Sites	Two-track	N/A	0.30	0.30
	Graveled	N/A	0.10	0.10
	Bladed	0.75	0.075	0.10
Utility Lines	Water	N/A	0.35	----[1]
	Overhead Elec.	N/A	0.20	0.20
	Underground Elec.	N/A	0.35	----
Transportation Lines	Low Pressure Gas	N/A	0.90	----
	Intermediate Pres. Gas	N/A	0.25	----
Processing Area	Battery Site	N/A	0.020	0.020
	Access Roads	N/A	0.15	0.15
	Field Compressor	N/A	----	0.02 (0.5 acres / 24 producing wells)
	Sales Compressor	N/A	----	0.005 (1.0 acres / 240 producing wells)
	Plastic Line	N/A	----	0.5[2]
	Gathering Line	N/A	----	0.25
	Sales Line	N/A	----	0.075
Produced Water Management	Discharge Point	N/A	0.01	0.002
	Storage Impoundment	N/A	0.3	0.25
Total Disturbance		1.0	3.25	2.0

1. The operation disturbance for utilities assumes all utilities will be completed underground, and the land surface will be reclaimed so that no disturbance should remain except where noted.

2. Plastic lines within the processing area are assumed to disturb an average corridor with of 25 feet.

Roads can be permanent or temporary, depending on the success of the well. The initial construction can be for a temporary road; however, it is designed so that it can become permanent if the well produces. Not all temporary roads constructed are rehabilitated when the drilling stops. A temporary road is often used as access to other drill sites. The main roads and temporary roads, require graveling to be maintained as all-weather roads. This is especially important in the spring. Access roads may be required to cross public lands to a well site located on private or state lands. The portion of the access road on public land would require a BLM right-of-way.

Most conventional wells are drilled from a fixed platform while the majority of CBNG wells are drilled using a truck-mounted rig. Site preparation generally takes about a week before the drill rig is assembled. For moderate depth oil wells drilling generally takes 2 to 4 weeks, although deeper wells may require longer drilling time because of the geologic formations encountered. Wells drilled from a platform require more surface preparation and cause disturbance to a larger area for the ancillary facilities. CBNG wells are usually drilled in under a week and site preparation is typically less than for conventional wells.

Approximately 1 to 4 acres are impacted by well site construction. The area is cleared of large vegetation, boulders, or debris. Then the topsoil is removed and saved for reclamation. A level area from 1 to 4 acres is then constructed for the well site, which includes the reserve pit.

The well pad is constructed by bulldozers and motor scrapers. The well pad is flat (to accommodate the drill rig and support equipment) and large enough to store all the equipment and supplies without restricting safe work areas. The drill rig must be placed on “cut” material rather than on “fill” material to provide a stable foundation for the rig. The degree of cutting and filling depends on terrain; that is, the flatter the site, the less dirt work is required.

Hillside locations are common, and the amount of dirt work varies with the steepness. A typical well pad will require a cut 10 feet deep against the hill and a fill 8 feet high on the outside. It is normal to have more cut than fill to allow for compaction, and any excess material is then stockpiled. Eventually, when the well is plugged and abandoned, excavated material is put back in its original place.

Reserve pits are normally constructed on the well pad. Usually the reserve pit is excavated in “cut” material on the well pad. The reserve pit is designed to hold drill cuttings and used drilling fluids. The size and number of pits depends on the depth of the well, circulating system and anticipated down hole problems, such as excess water flows.

Reserve pits are generally square or oblong, but may be irregular in shape to conform to terrain. The size of reserve pits for deeper wells can be reduced by the use of steel mud tanks. For truck-mounted drill rigs used in shallow gas fields, a small pit (called the blooie pit) is used. Most or all of the reserve pit is located in the cut location of the drillsite for stability. When the drillsite is completed, the rig and ancillary equipment are moved on location and drilling begins.

The reserve pit can be lined with a synthetic liner to contain pit contents and reduce pit seepage. Not all reserve pits are lined; however, BLM often requires a synthetic liner depending upon factors such as soils, pit locations, ground water and drilling mud constituents. The operator can elect to line the reserve pit without that requirement.

An adequate supply of water is required for drilling operations and other uses. The sources of water can be a well at the drill site or remote sources such as streams, ponds, or wells. The water is transported to the site by truck or pipeline. Pipelines are normally small diameter surface lines. The operator must file for and obtain all necessary permits for water from the state. On public lands an operator must have the BLM’s permission before surface water can be used.

9.3 Mitigation Measures

Mitigation measures are restrictions on lease operations, which are intended to minimize or avoid adverse impacts to resources or land uses from oil and gas activities. The mitigation measures listed in Table 8-5 would be applied to permits, leases or approvals granted by the land management agency. The list is not all inclusive, but presents the mitigation measures most often used in the Jackson Field Office RMP area. The wording of the mitigation measure may be modified or additional measures may be developed to address specific conditions. Mitigation measures would be included as appropriate to address site-specific concerns during all phases of oil, gas and CBNG development.

9.4 Conditions of Approval

An approved application for permit to drill (APD) includes conditions of approval (COA), and Informational Notices which cite the regulatory requirements from the Code of Federal Regulations, Onshore Operating Orders and other guidance. Conditions of approval are mitigation measures which implement lease restrictions to site specific conditions. General guidance for COA are found in the BLM and U.S. Forest Service brochure entitled “Surface Operating Standards for Oil and Gas Exploration and Development” (USDI, BLM 1989) and BLM Manual 9113 entitled “Roads”.

9.5 Lease Stipulations

Certain Resources in the planning area require protection from impacts associated with oil and gas development. The specific resources and methods of protection are contained in lease stipulations. Lease stipulations usually consist of no surface occupancy, controlled surface use, or timing limitations. A notice may be included with a leased to provide guidance regarding resources or land use. While actual wording of stipulations may be adjusted at the time of leasing, the protection standard described will be maintained.

9.6 Total Disturbances

The disturbances for the RFD scenario over the next ten years have been calculated and are displayed in Tables 21 and 22. Table 21 addresses the disturbances from exploration and construction activities for well types anticipated to be developed across the state. Estimates for horizontal gas and CBNG have not been extrapolated due to the limited information regarding their potential and lack of recent drilling. The total disturbances for all predicted wells are estimated at 21,157 acres. Disturbance from federal mineral development would be 3,358 acres of which 3,272 acres would be on USFS lands. The remaining federal disturbance (86 acres) would be on military sites, national park lands, and USFWS refuges. The disturbance to state and fee lands would be 16,664 acres.

Table 22 depicts the residual disturbance by well type remaining after appropriate mitigation measures and site restoration or rehabilitation activities have taken place. The total residual disturbance from anticipated development activities is 7,566 acres of which 1,269 would be from federal mineral development. The federal disturbances would affect 1,236 USFS acres and 33 acres of various surface agencies. State and fee residual disturbance would be 6,297 acres.

The mitigation of initial exploration and construction disturbances would equal nearly 13,591 acres. Mitigation measures would account for remediation of 2,089 federal acres, and 10,367 state and fee acres.

Table 21: Predicted Development and Surface Disturbance (Exploration and Construction) for Wells

Well Type	Total Wells Drilled	Dry Holes	Disturbance per Dry Hole	Total Dry Hole Disturbance	State & Fee Producing Wells	Disturbance per State/Fee Well	Total State/Fee Disturbance	Federal Producing Wells	Disturbance per Federal Well	Total Federal Disturbance	USFS Producing Wells	Disturbance per USFS Well	Total USFS Disturbance	Total Producing wells	Total Disturbance
Oil – shallow	1,278	348	2.43	845.64	902	4.79	4,320.58	5	4.79	23.95	23	4.79	110.17	930	5,300.34
Gas – shallow	3,369	119	2.43	289.17	2,577	4.79	12,343.830	13	4.79	62.27	660	4.79	3,161.40	3,250	15,856.67
CBNG	0	0	1.0	0	0	3.25	0	0	3.25	0	0	3.25	0	0	0
Gas – horizontal	0	0	3.43	0	0	6.9	0	0	6.9	0	0	6.9	0	0	0
Total	4,647	467		1,134.81	3,479		16,664.41	18		86.22	683		3,271.57	4,180	21,157.01

Assumptions:

Disturbance per well includes the well pad plus incremental roads, utility lines, transportation lines, processing equipment areas, and produced water management as outlined in Tables 11,12,13,& 14 for exploration.

Table 22: Predicted Development and residual Surface Disturbance (Production) for Wells

Well Type	Total Wells Drilled	State & Fee Producing Wells	Disturbance per State/Fee Well	Total State/Fee Disturbance	Federal Producing Wells	Disturbance per Federal Well	Total Federal Disturbance	USFS Producing Wells	Disturbance per USFS Well	Total USFS Disturbance	Total Producing wells	Total Disturbance
Oil – shallow	1,278	902	1.81	1,632.62	5	1.81	9.05	23	1.81	41.63	930	1,683.30
Gas – shallow	3,369	2,577	1.81	4,664.37	13	1.81	23.53	660	1.81	1,194.60	3,250	5,882.50
CBNG	0	0	2.0	0	0	2.0	0	0	2.0	0	0	0
Gas – horizontal	0	0	2.21	0	0	2.21	0	0	2.21	0	0	0
Total	4,647	3,479		6,296.99	18		32.58	683		1,236.23	4,180	7,565.80

Assumptions:

Disturbance per well is the residual disturbance remaining after the mitigation measures have been implemented.

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APPENDIX A

USGS Fact Sheet FS-115-99 – Coal Resource Assessment in the Northern and Central Appalachian Coal Region

USGS Fact Sheet 2004-3092 - Assessment of Undiscovered Carboniferous Coal-Bed Gas Resources of the Appalachian Basin and Black Warrior Basin Provinces, 2002

USGS Fact Sheet 3058 - Assessment of Undiscovered Oil and Gas Resources of the Illinois Basin, 2007

USGS Fact Sheet 018-99 – Kentucky

APPENDIX B

USGS Open-File Report 2004-1272 - Assessment of Appalachian Basin Oil and Gas Resources: Carboniferous Coal-bed Gas Total Petroleum System

USGS Open-File Report 2006-1048 - An Allocation of Undiscovered Oil and Gas Resources to Big South Fork National Recreation Area and Obed Wild and Scenic River, Kentucky and Tennessee

USGS Assessment Report - ILLINOIS BASIN PROVINCE (064)

USGS Assessment Report - CINCINNATI ARCH PROVINCE (066)

USGS Assessment Report - APPALACHIAN BASIN PROVINCE (067)